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THE PENNSYLVANIA
STATE UNIVERSITY

IONOSPHERIC RESEARCH

Scientific Report (D) No. 179

LOW FREQUENCY SWEEP GROUP HEIGHT AND POLARIZATION RECORDS

by
J. D. Hardy
February 15, 1963

"The research reported in this document has been sponsored by the Geophysics Research Directorate of the Air Force Cambridge Research Laboratory, Office of Aerospace Research, United States Air Force, under Contract AF19(604)-8012."

IONOSPHERE RESEARCH LABORATORY

University Park, Pennsylvania

Contract No. AF19(604)-8012
Project 8605, Task 860501

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IONOSPHERIC RESEARCH

Contract AF19(604)-8012

Scientific Report

on

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J. D. Hardy

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SCIENTIFIC REPORT NO. 179

Ionosphere Research Laboratory

Submitted by: ______________________
A. J. Ferraro, Assistant Professor of
Electrical Engineering

a.H. Waynick
Approved by: ______________________
A. H. Waynick, Professor of Electrical
Engineering, Director, IRL

THE PENNSYLVANIA STATE UNIVERSITY

College of Engineering and Architecture

Department of Electrical Engineering

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ABSTRACT

This report is a presentation of the records obtained during the period March 5, 1962 to August 22, 1962 on a low frequency group height and polarization instrumentation covering the swept frequency range of 100 - 1000 Kc/s. Included in these data are the preliminary results of a stepped frequency experiment. These appear to be the only such records being obtained in the world at this time. In view of this, it was deemed advisable to make them available to the scientific community by this process.

I. Introduction

Automatic h'-f recordings over a range of about 1 to 30 Mc/s are made regularly in different parts of the world, from which the structure of the ionosphere from about 100 Km to the height of maximum electron density can be deduced. For determining the structure of the lower ionosphere, lower frequencies are required since their depth of penetration before reflection is smaller. Equipment for this purpose involving the recording of virtual height in the range 100 - 1000 Kc/s has been designed and constructed at the Ionosphere Research Laboratory.(1)

As an adjunct to the long wave h'-f equipment it is imperative to determine the sense of rotation of the ionospheric echoes as a function of frequency to aid in the analysis of the very complicated structure of the low frequency echoes.

Parkinson(2) used a crossed pair of loop antenna at a fixed frequency of 150 Kc/s to measure the complete polarization characteristics. In this technique, the phase of the signal in one loop is advanced by $^{\pi}/4$ and that of the other loop retarded by the same amount. The circular components, ordinary and extraordinary, are formed by the sum and difference of the phase shifted loop signals.

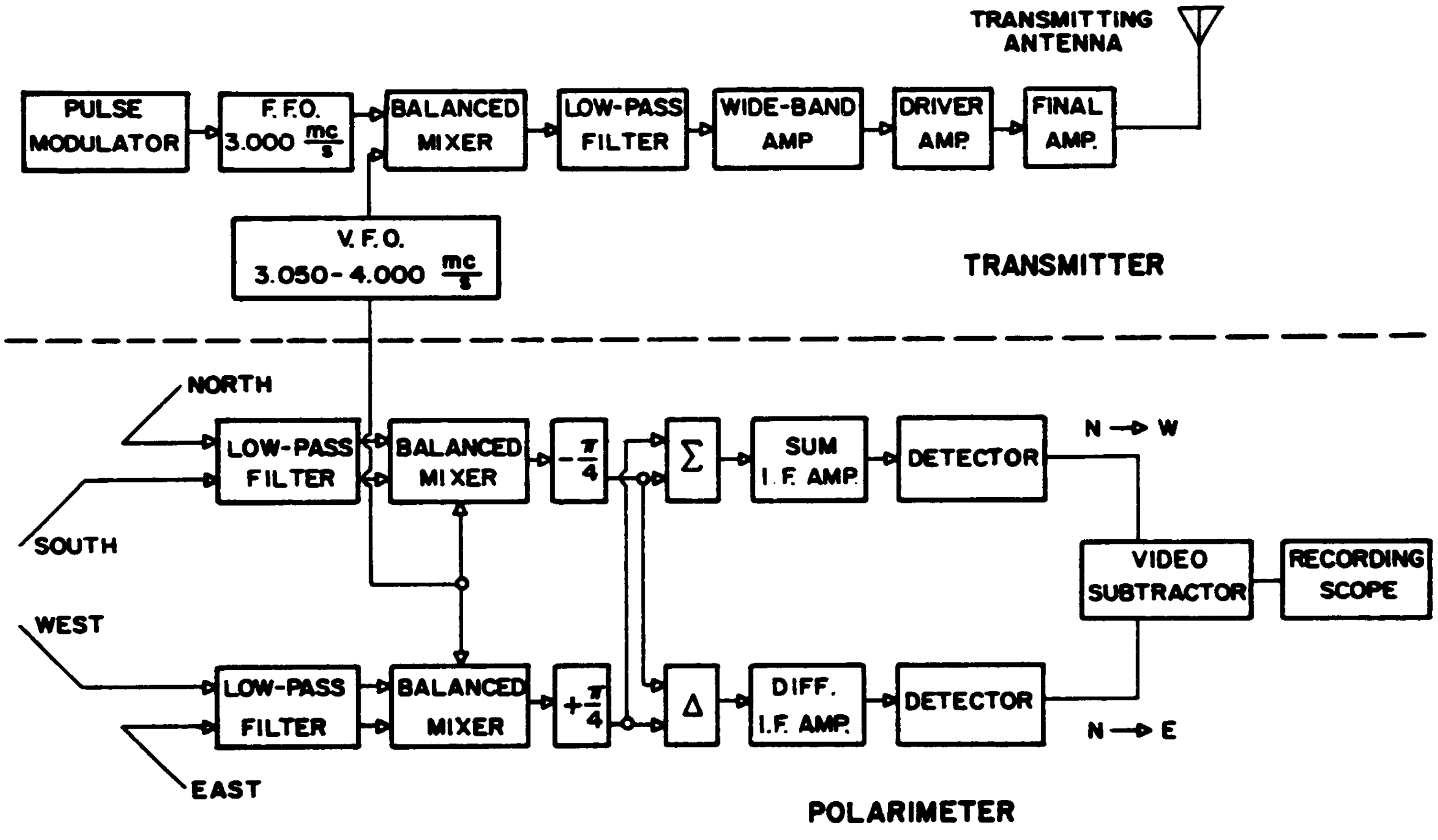
Carlson(3) adapted Parkinson's fixed frequency method to sweep frequencies as far as polarization sense determination is concerned. Carlson's polarimeter, which is in operation at the Ionosphere Research Laboratory at the present time, was used to obtain such recordings in this report.

Figure 1 is a block diagram of the transmitter and polarimeter. The output from the variable frequency oscillator (3.1 Mc/s-4 Mc/s) of the transmitter is mixed with received signals (100 Kc/s-1000 Kc/s) resulting in a 3 Mc/s signal for intermediate frequency amplification.

The Parkinson technique is applied, but at the I.F frequency of 3 Mc/s, producing two outputs corresponding to the North into West and North into East circular components. These outputs are further subtracted by a video amplifier and then used to intensity modulate the recording oscilloscope. In this manner, records are obtained with black and white traces corresponding to a predominantly North into East rotation and North into West rotation; respectively. For a more detailed description and the theory of operation it is suggested that the reader refer to Carlson's Scientific Report No. 129(3).

II. INTERPRETATION OF RECORDS

All the records presented in the Appendix of this report cover the period March 5, 1962 to August 22, 1962. The times are Eastern Standard and the twenty-four hour system was used to indicate the time. Times and dates are marked at the bottom of each page, while times of individual records are printed adjacent to each of the records to facilitate their reading.


TRANSMITTING ANTENNA
PULSE MODULATOR
F.F.O. 3.000 mc/s
BALANCED MIXER
LOW-PASS FILTER
WIDE-BAND AMP
DRIVER AMP.
FINAL AMP.
V.F.O. 3.050-4.000 mc/s
TRANSMITTER
NORTH
SOUTH
WEST
EAST
LOW-PASS FILTER
BALANCED MIXER
$-\frac{\pi}{4}$
$+\frac{\pi}{4}$
Σ
Δ
SUM I.F. AMP.
DIFF. I.F. AMP.
DETECTOR
DETECTOR
N → W
N → E
VIDEO SUBTRACTOR
RECORDING SCOPE
POLARIMETER

EQUIPMENT BLOCK DIAGRAM

FIGURE I

It will be noted that the length of some of the records are longer than others; those which were recorded before May were on a four minute sweep length and those afterward on a two minute sweep.

Frequency markers occur every 100 Kc/s and the corresponding height intervals are 10 Km steps. During March and April a mechanical frequency marker was used and its accuracy at times was in question; however, the drawn-in frequency scale on each of these pages will give a fairly accurate indication of frequency. After April the electronic frequency marker was in use again and now gives accurate frequency markers.

On some of the records, frequency increases from right to left; in this case, a frequency scale has been drawn in on the lower right hand corner of each page. For the majority of prints the frequency increases from left to right.

On the side of one of the bottom prints there is a height scale in hundreds of kilometers. This scale may be used with those records on that page. At times it may be noted that the 100 Km marker may appear closer to the base of the record. This is caused by occasional drift of the image on the oscilloscope.

At the bottom of the page along with the time and date is the magnetic C-figure for that day. The C-figure is the arithmetic mean of the subjective classification by all observatories of each day's magnetic activity on a scale of

0(quiet) to 2(storm). These values were obtained from The Solar Geophysical Data, published by The National Bureau of Standards, Central Radio Propagation Laboratory, Boulder, Colorado.

The dark echoes indicate a north into east polarization sense and light echoes indicate a north into west sense.

Occasionally an experiment was made in which the frequency was stepped across the range 100 - 400 Kc/s instead of being swept continuously from 100 - 1000 Kc/s. Five steps were used of approximately ten minutes each, corresponding to 100, 150, 200, 300 and 400 Kc/s. These were the only licensed fixed-frequencies which were feasible for use. The 100 Kc/s step does not usually produce any echoes and serves as a frequency origin. The frequency of each step is printed in with white ink, with the frequency coming at the beginning of the step. Care in reading these must be exercised because of the reversed prints in some cases. On most of the step records, the frequency and height markers appears at equal intervals. These are triggered by a motor and time switch at the rate of one per minute.

III. BIBLIOGRAPHY

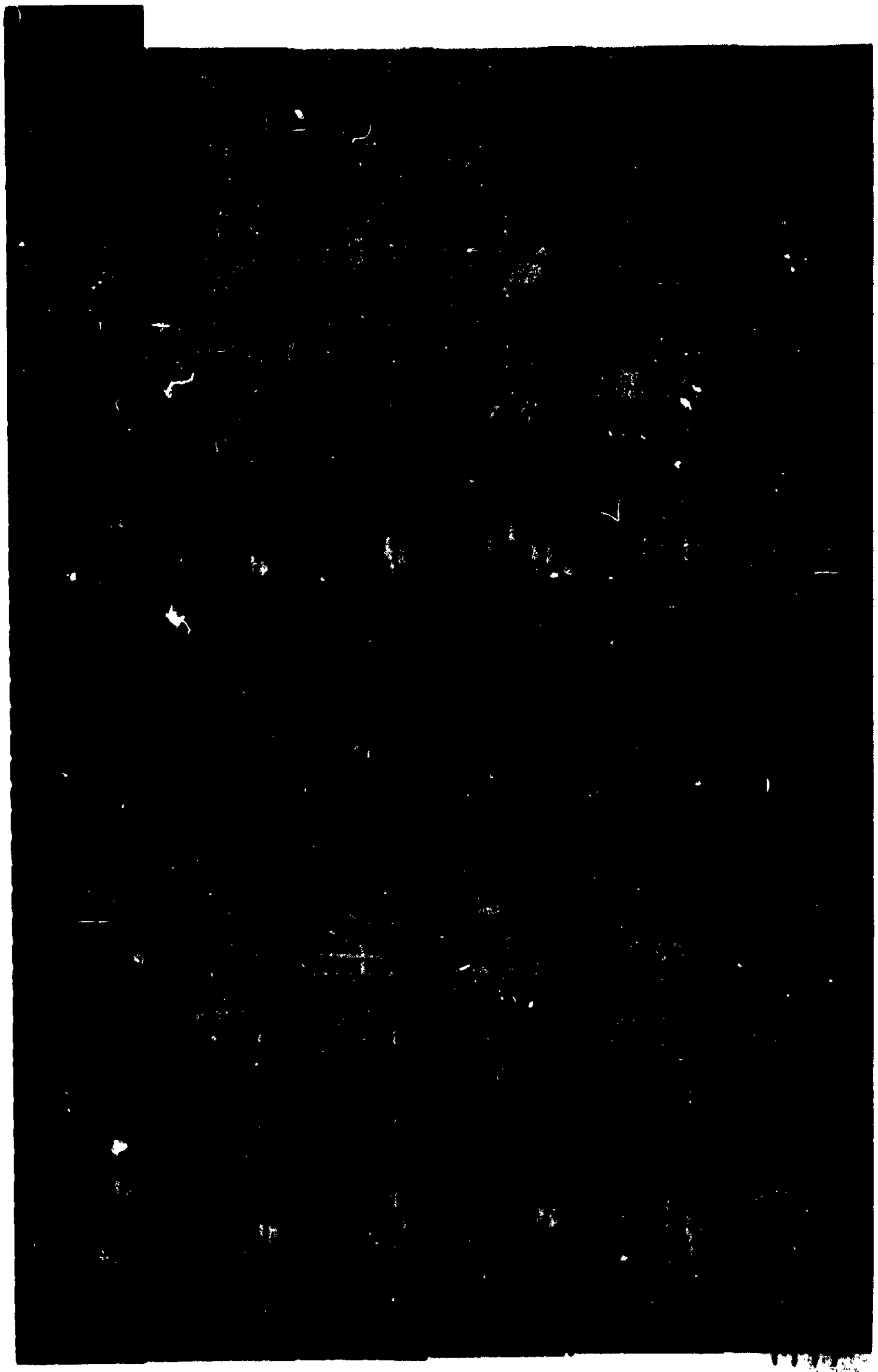
1. Sechrist, C.F., Jr., Scientific Report No. 103, Ionosphere Research Laboratory, University Park, Pa. (1958).

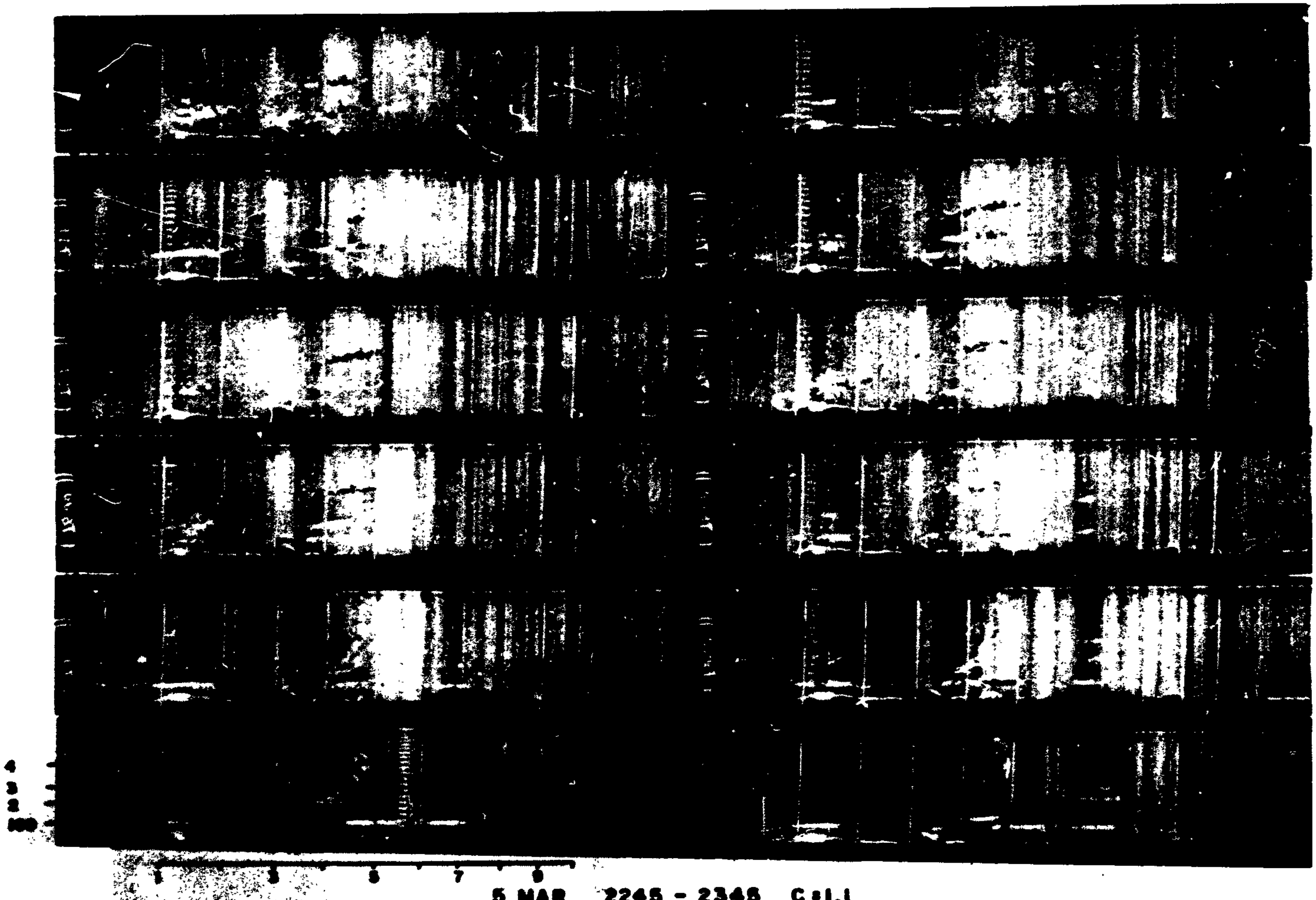
2. Parkinson, R.W., Rev. Sci. Inst., 26, 319 (1955).

3. Carlson, H.N., Scientific Report No. 129, Ionosphere Research Laboratory, University Park, Pa. (1960).

IV. APPENDIX

Sample low frequency sweep records, covering the frequency range 100 to 1000 Kc/s, obtained during the interval March 5, 1962 to August 22, 1962. These include group height and polarization sense information.





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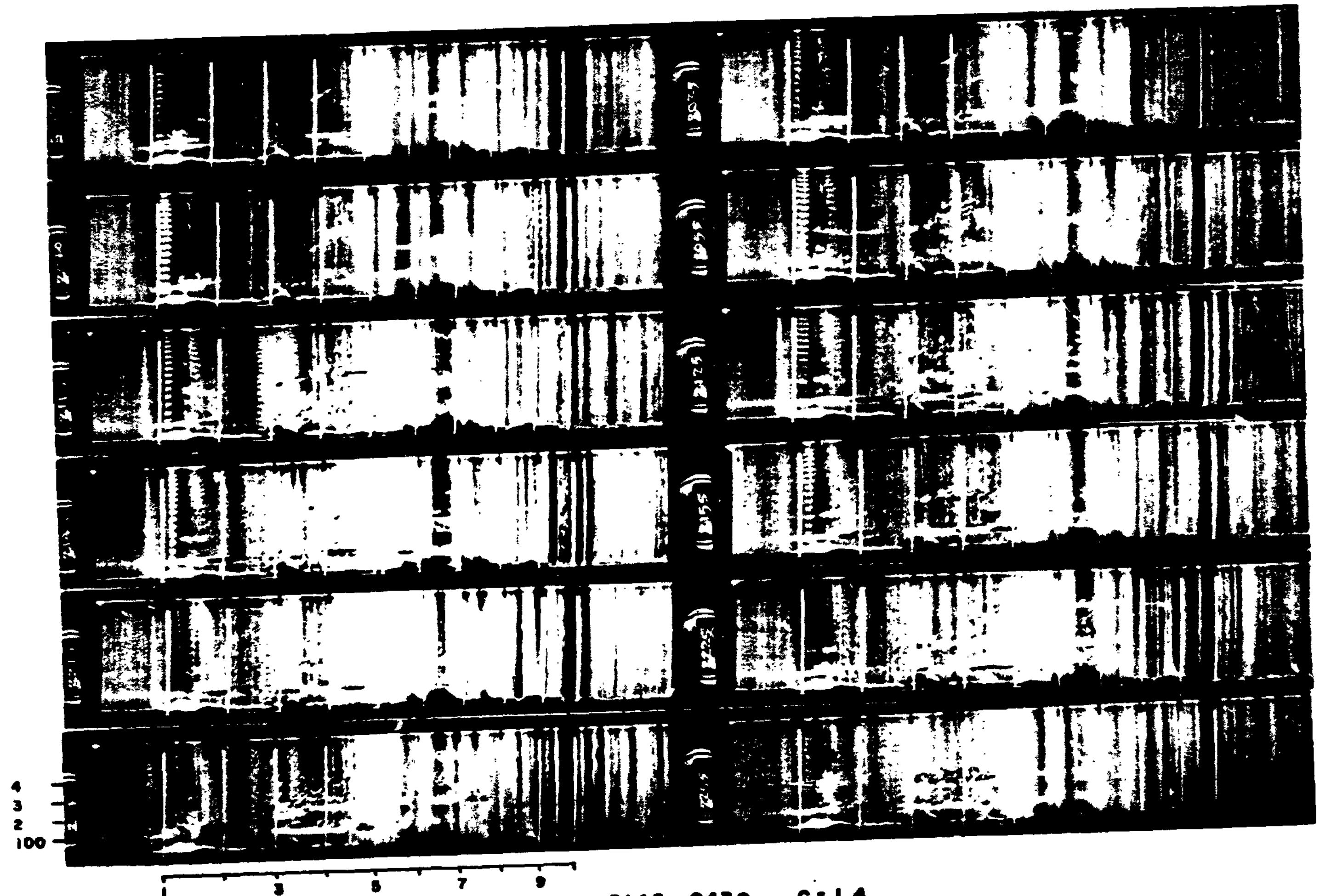
6 MAR 0000 - 0130 C=1.4



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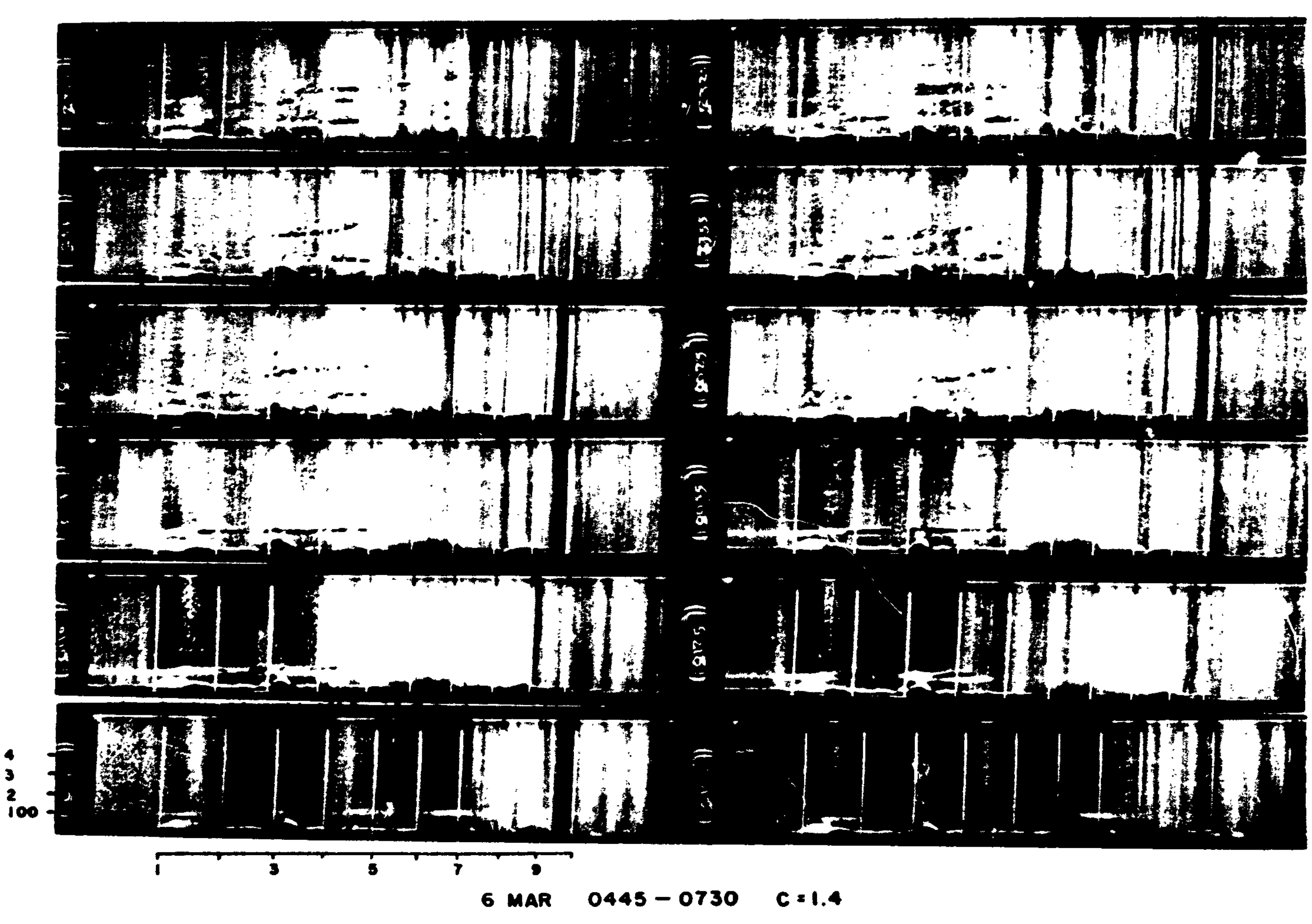

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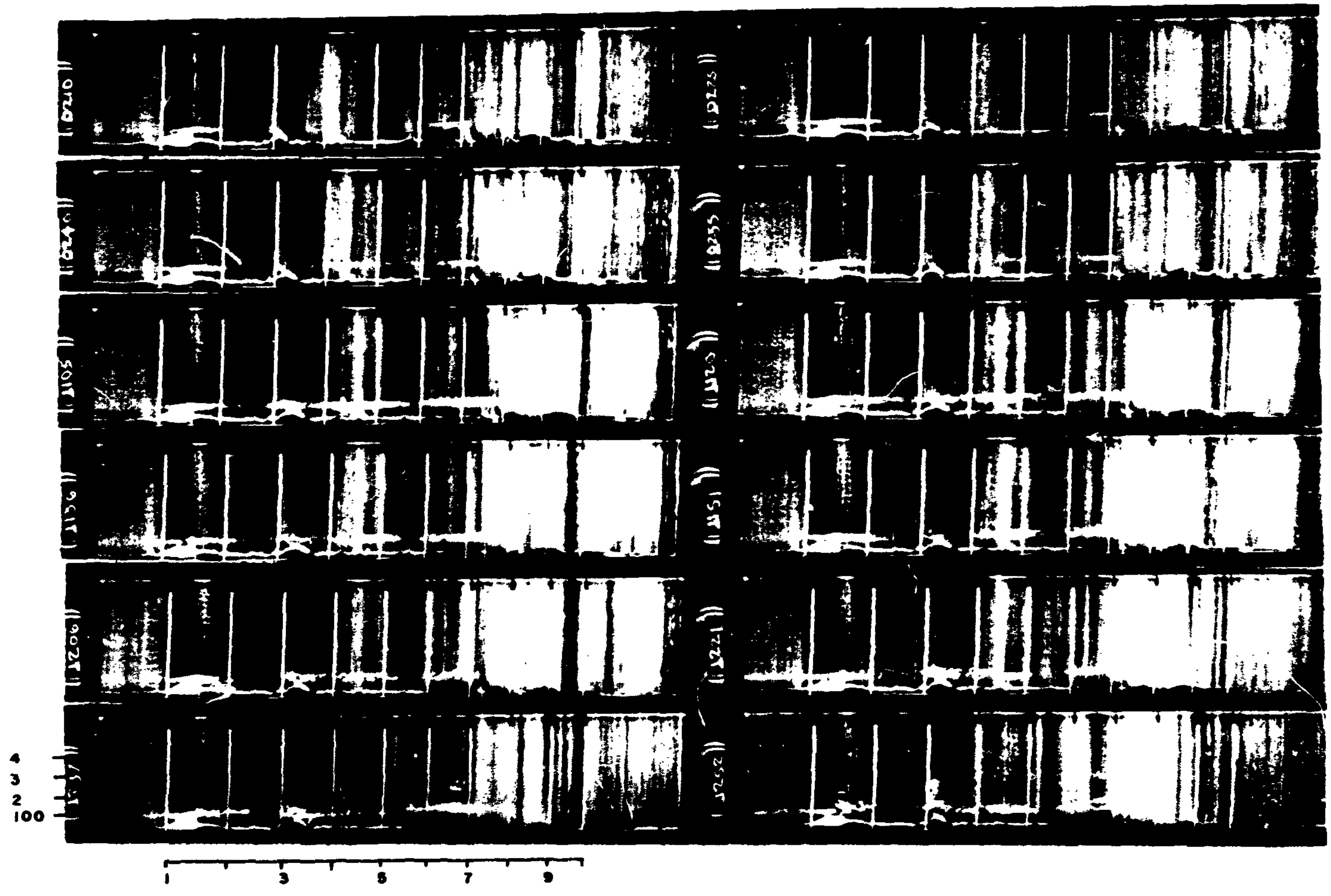
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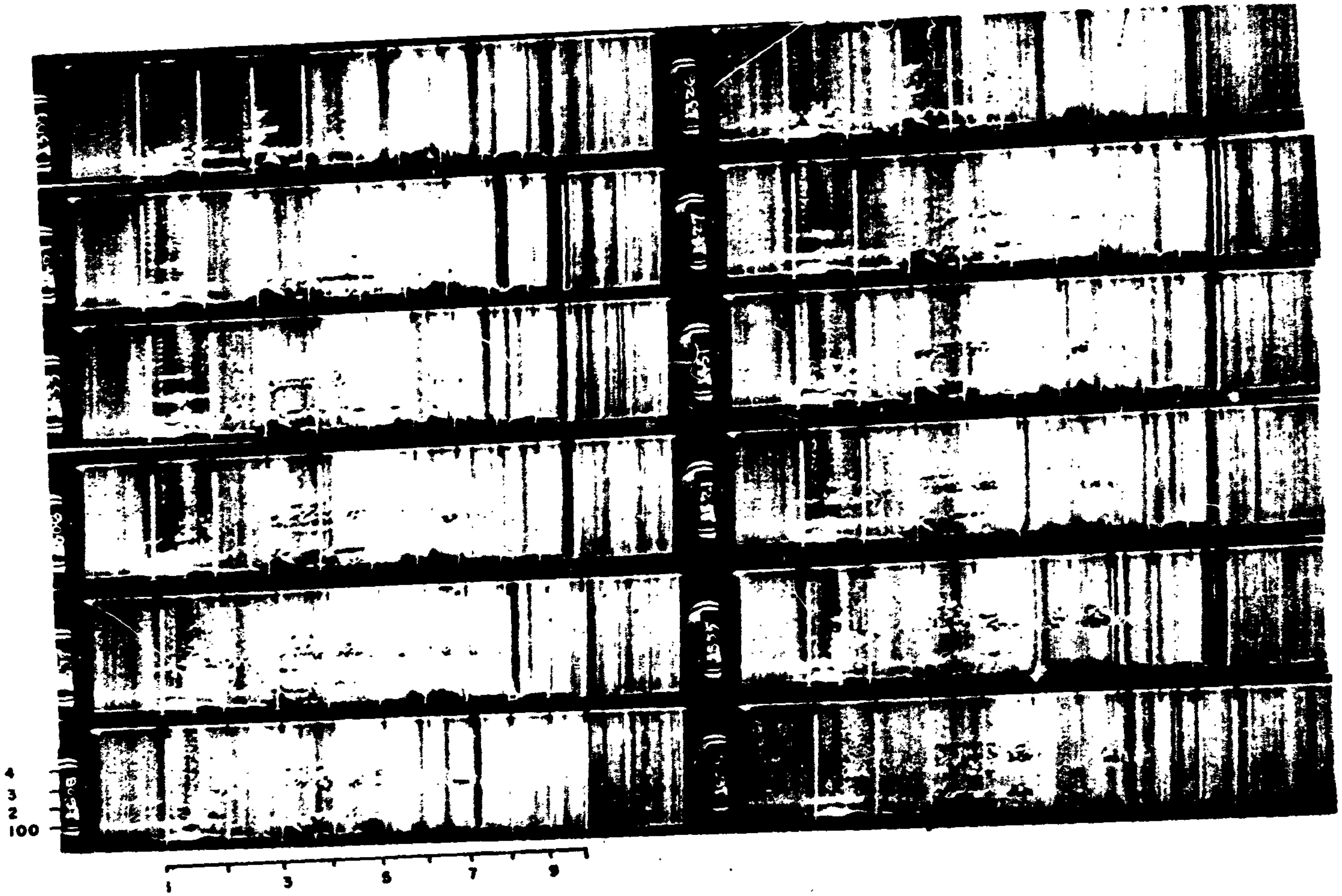
6 MAR 0745 - 0830 C = 1.4
6 MAR 1630 - 1830 C = 1.4



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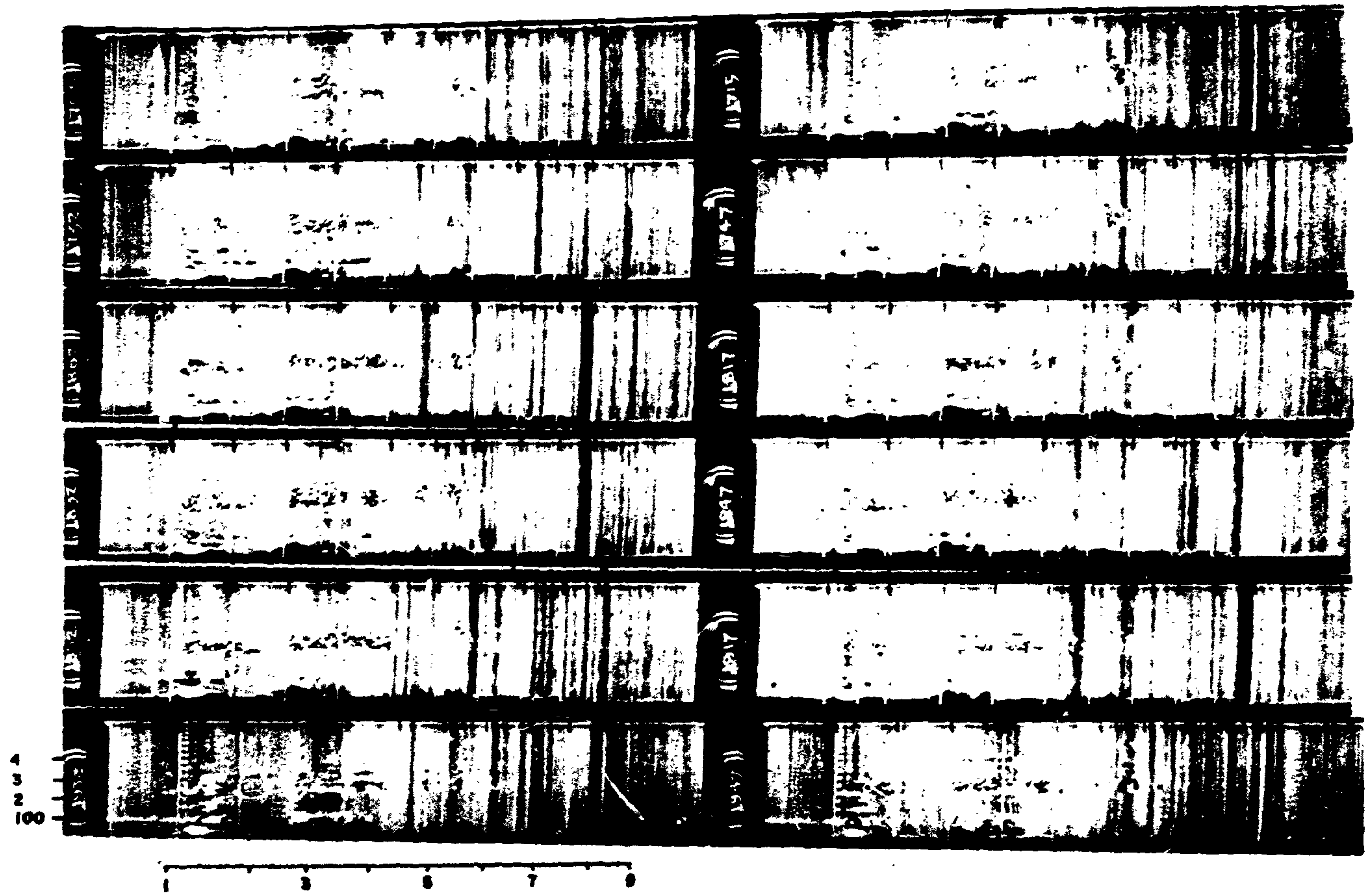

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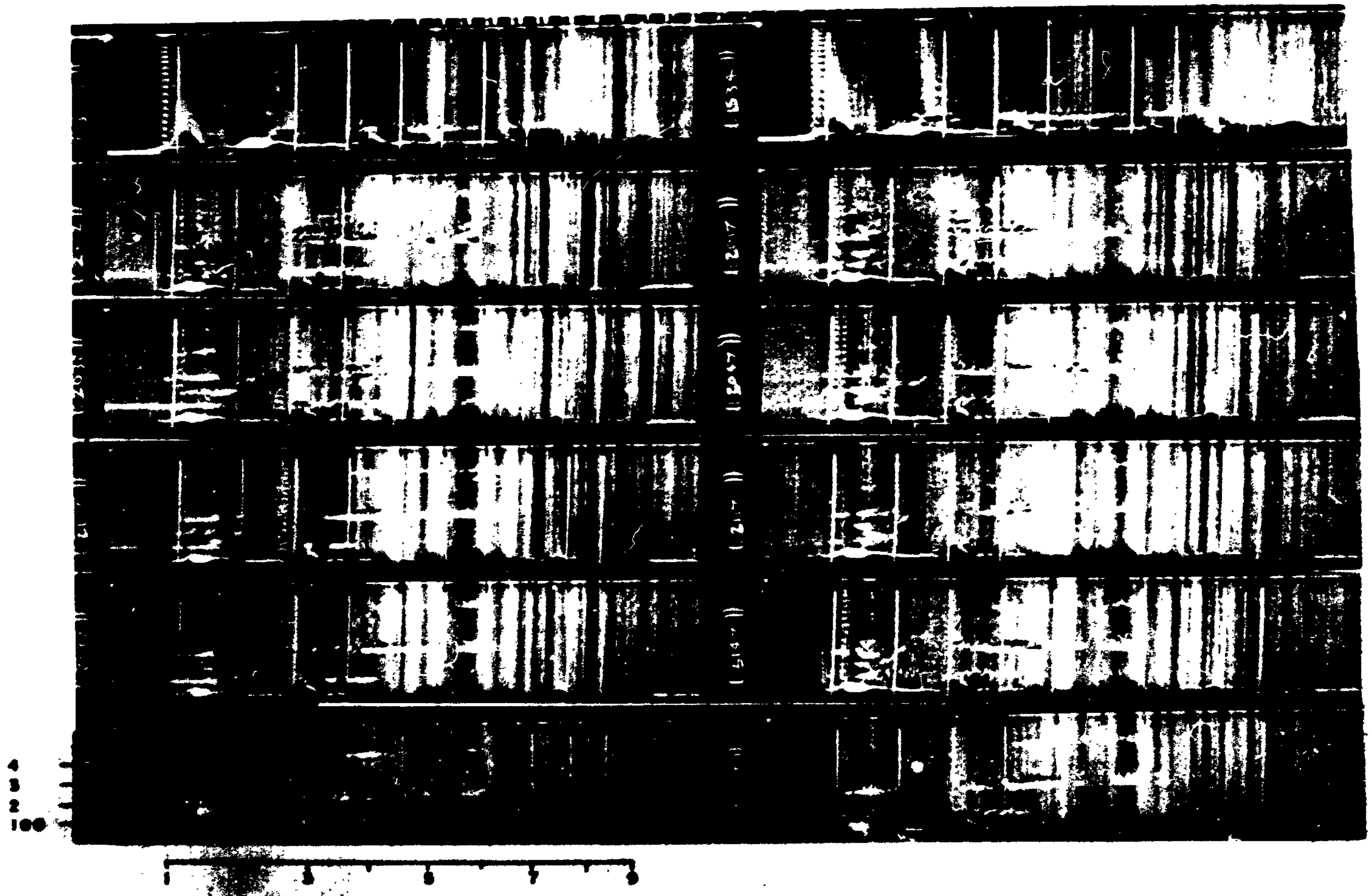
7 MAR 0000 - 0100 C = 0.3



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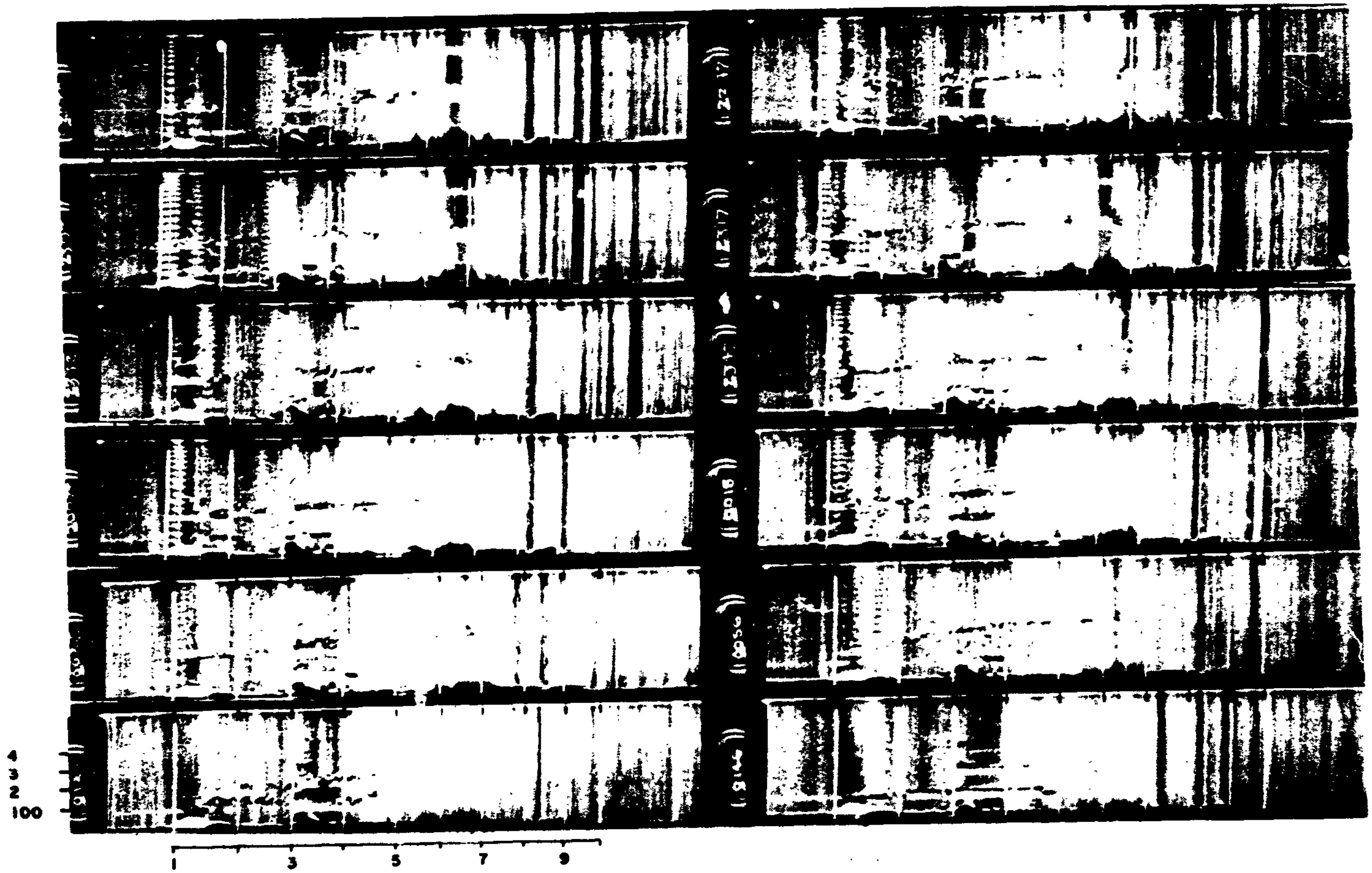

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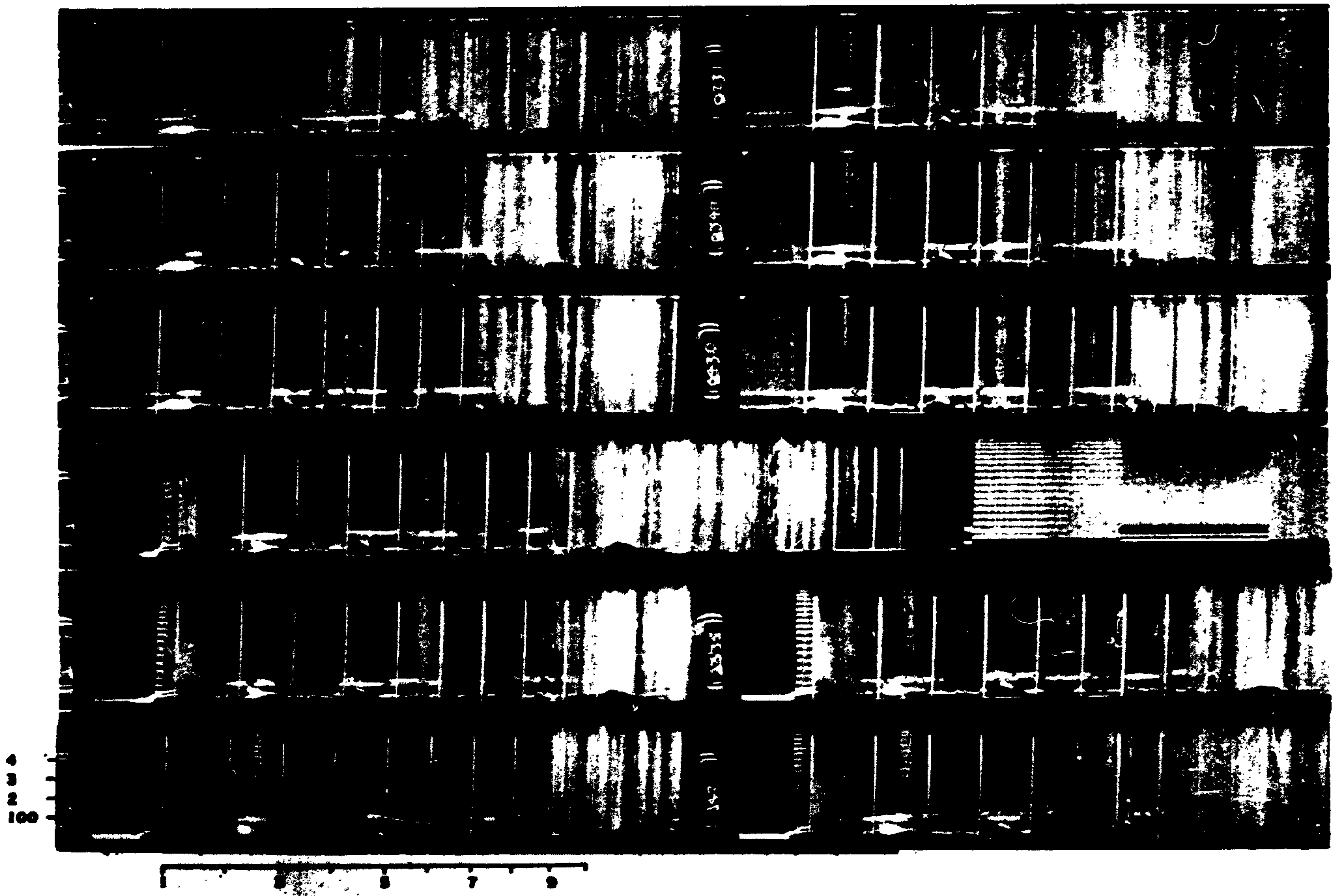

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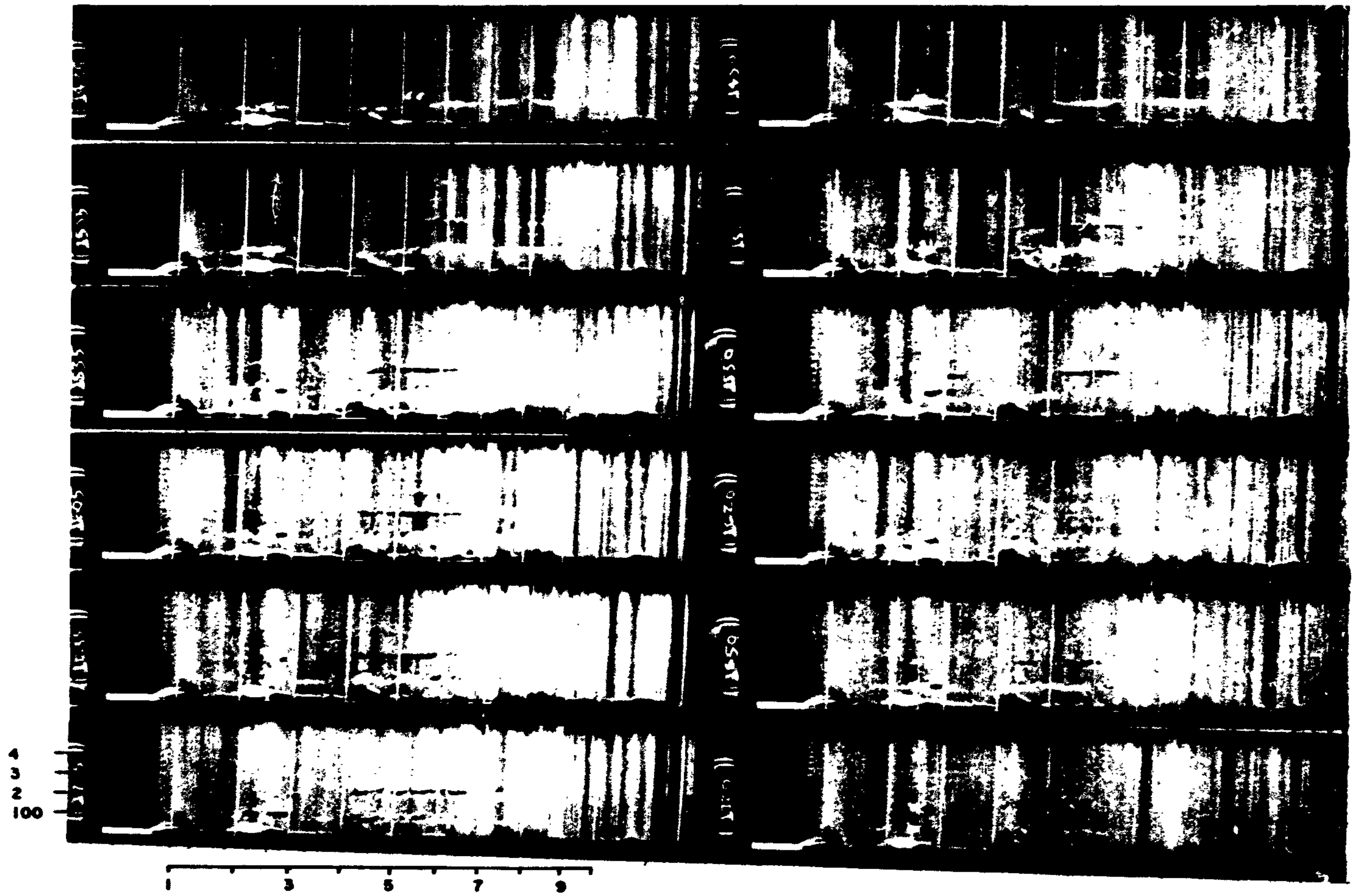

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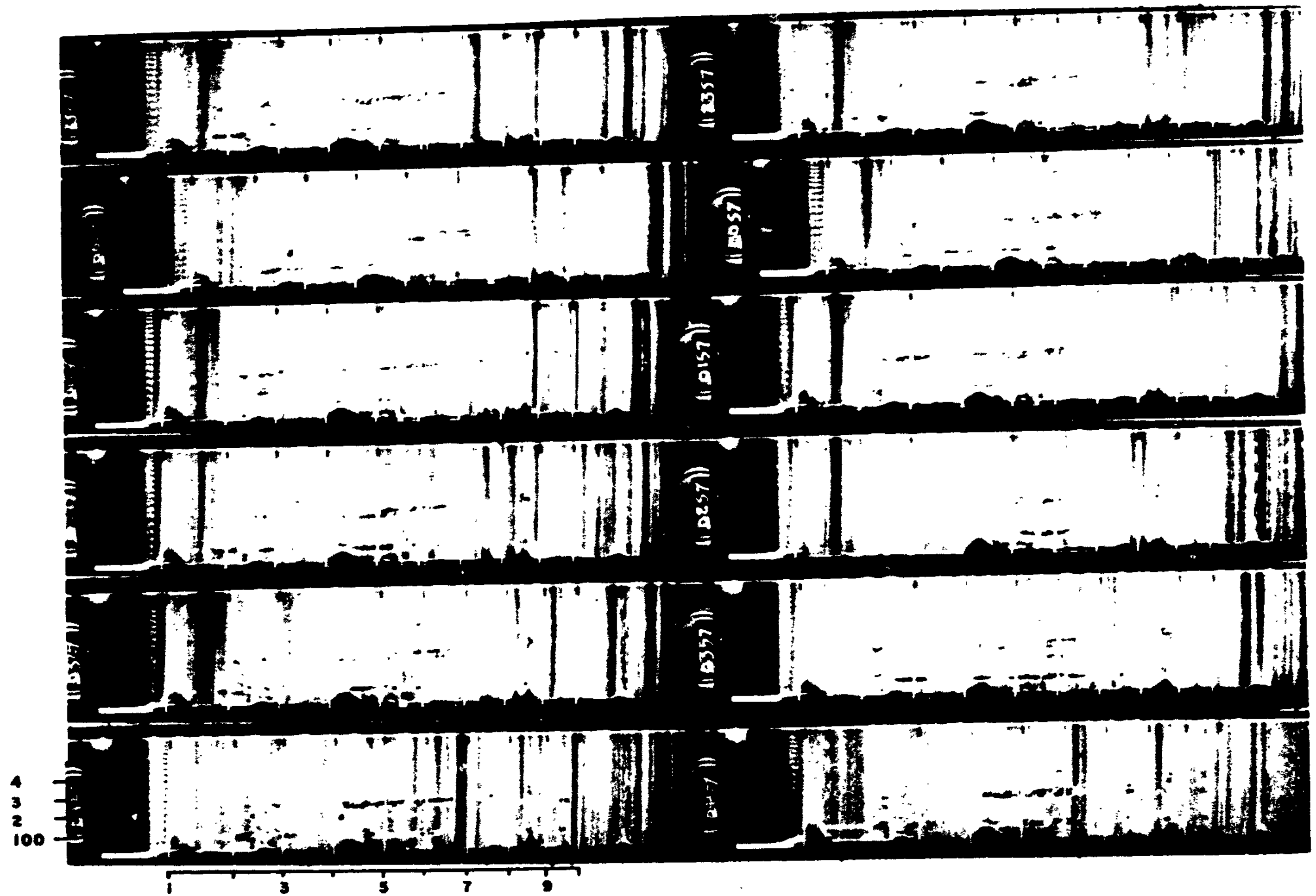
7 MAR 2115 -2415 C=0.3



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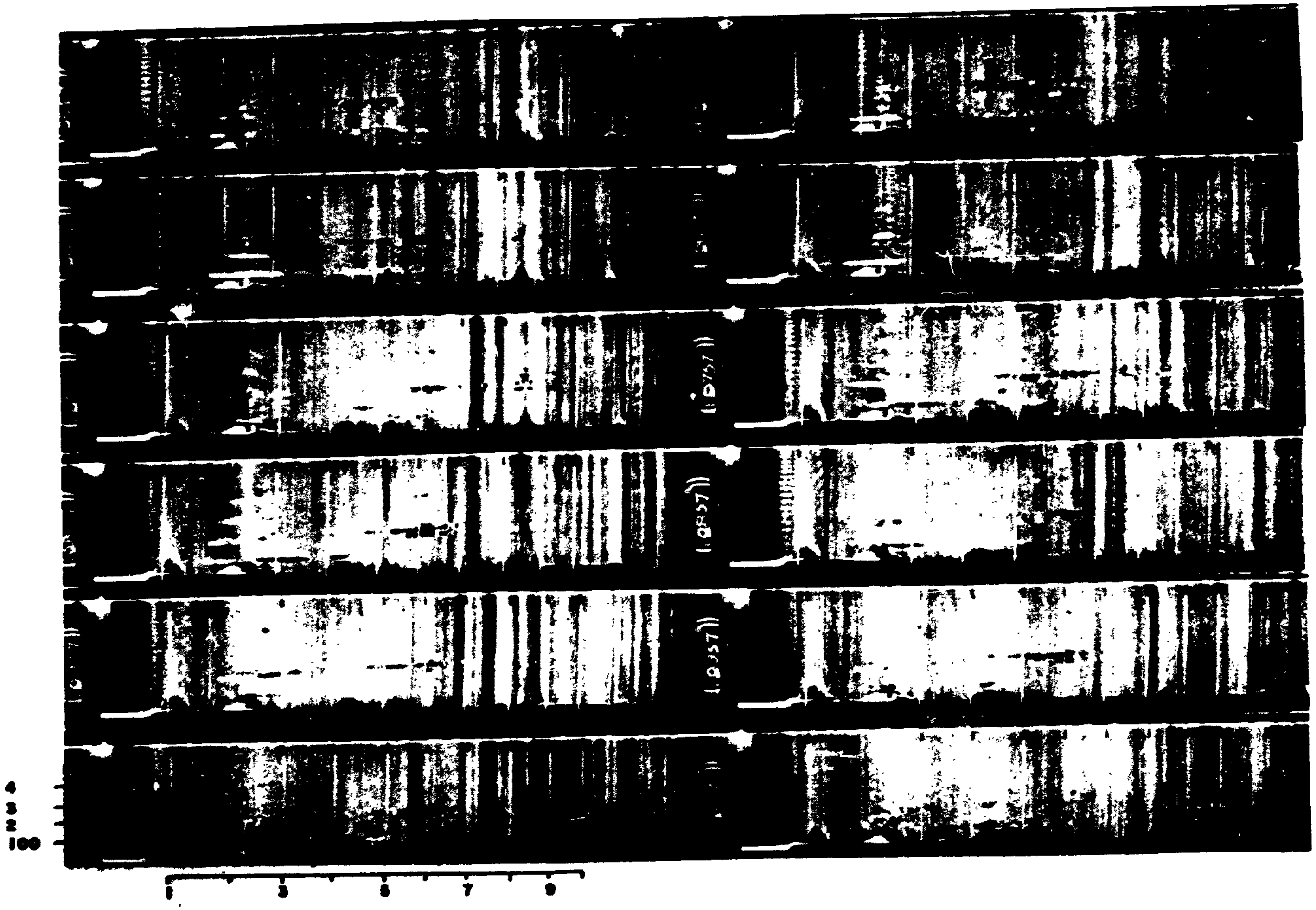

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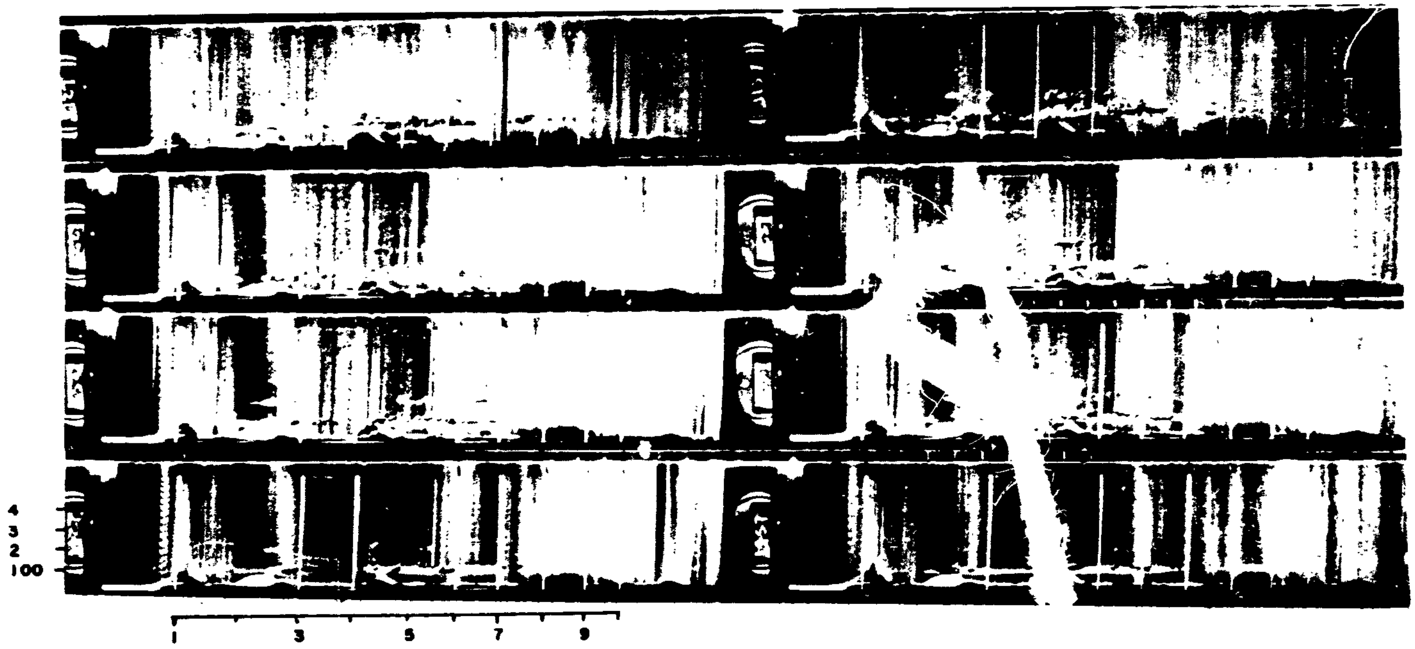

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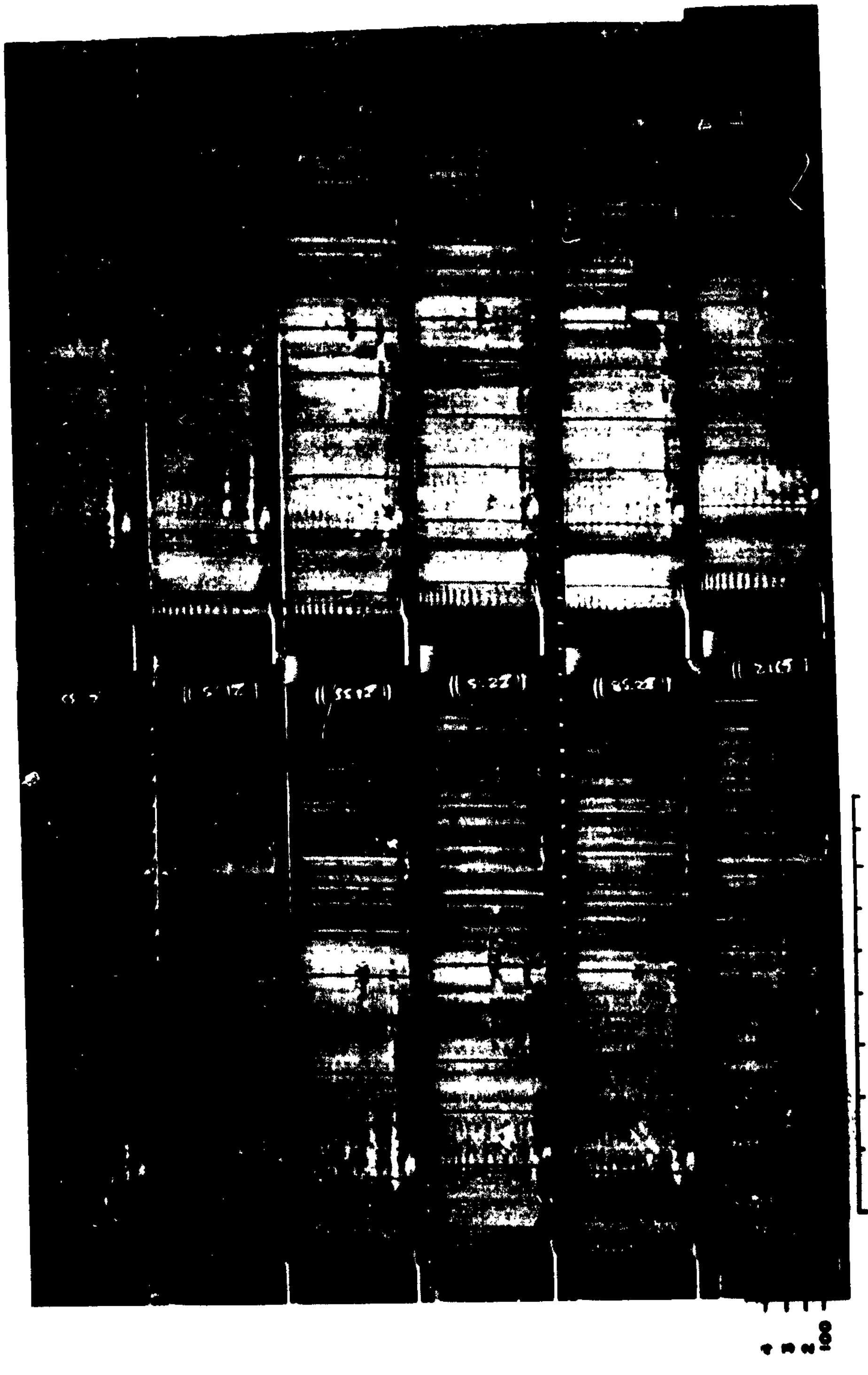

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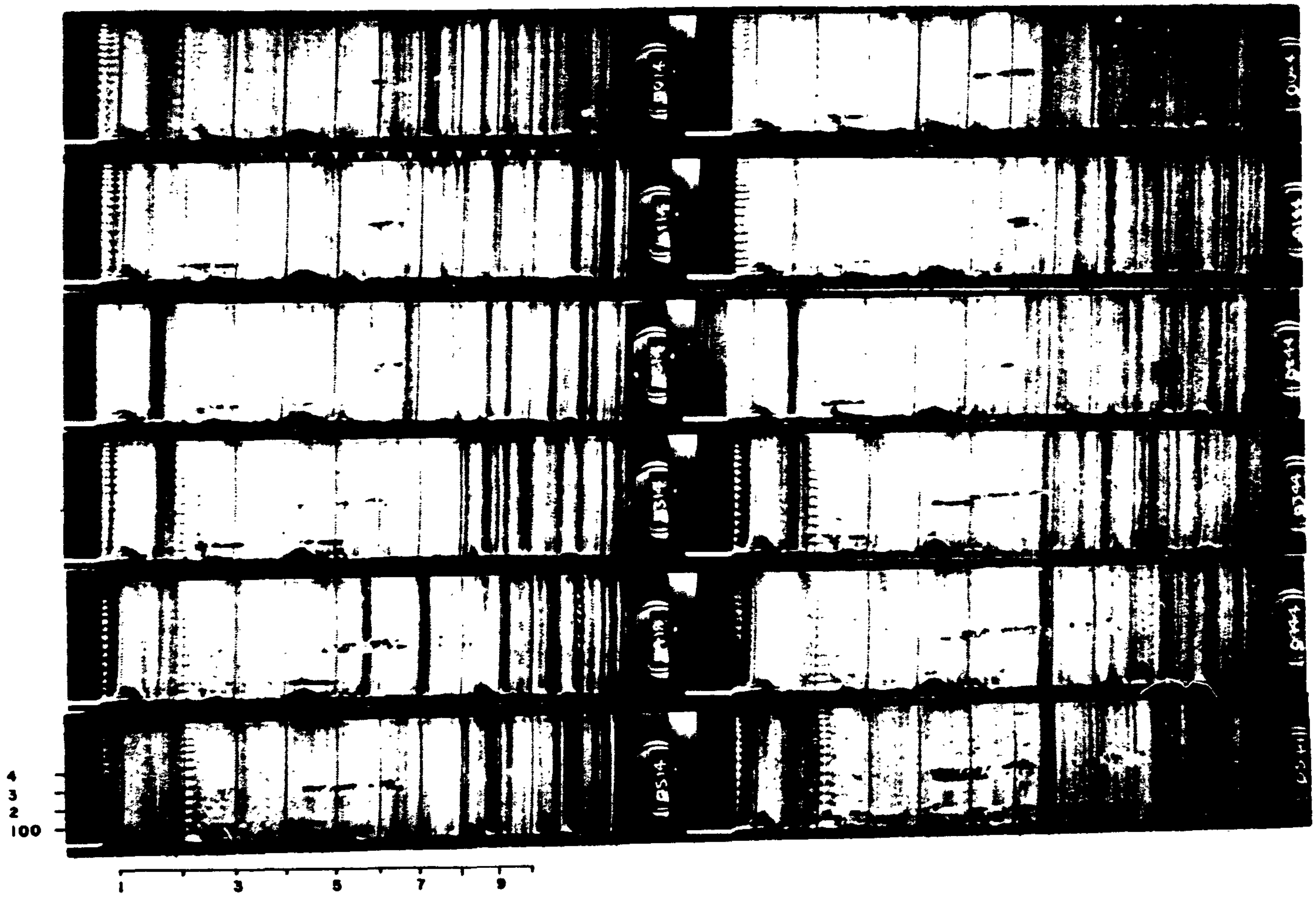

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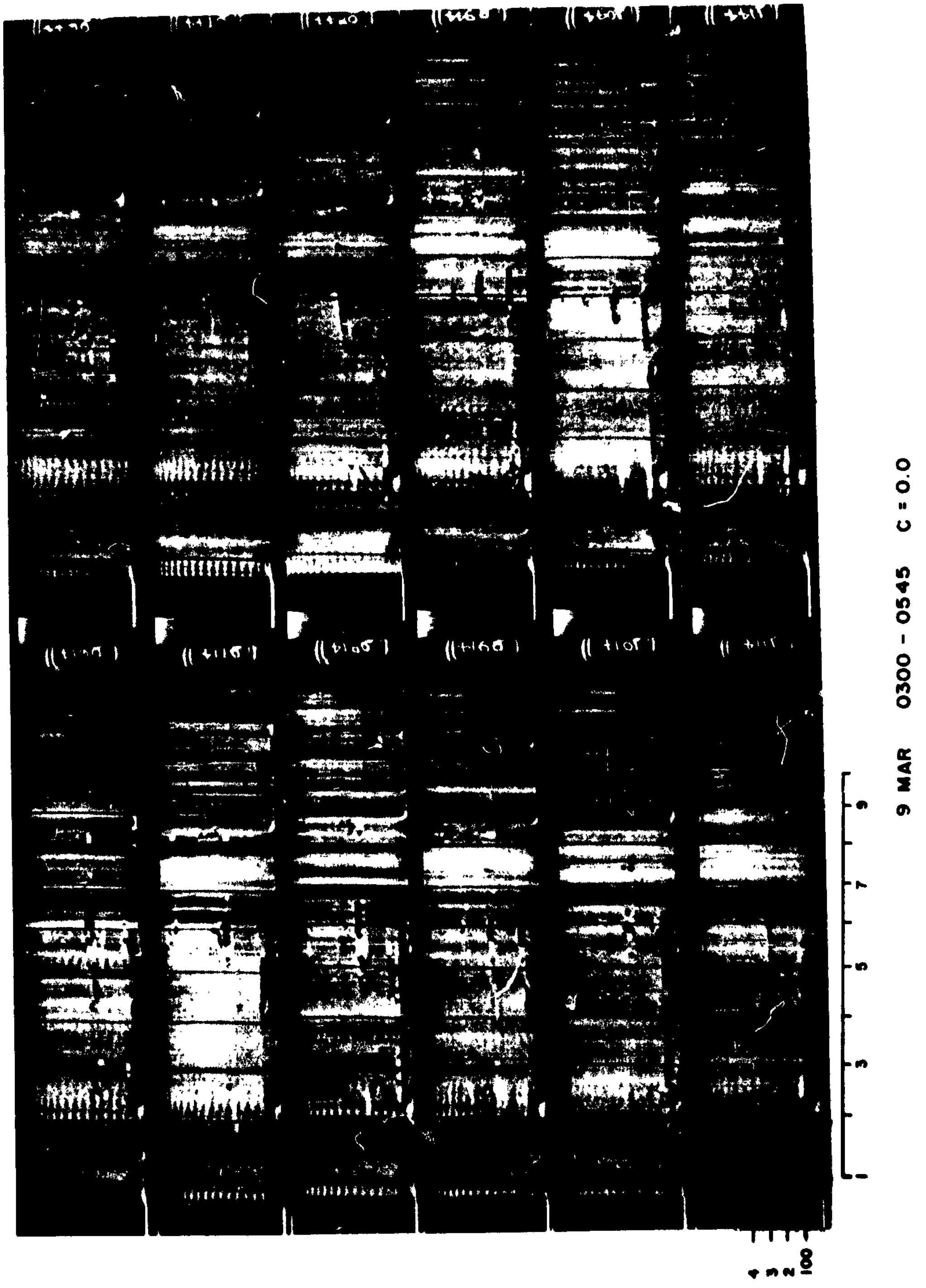
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5
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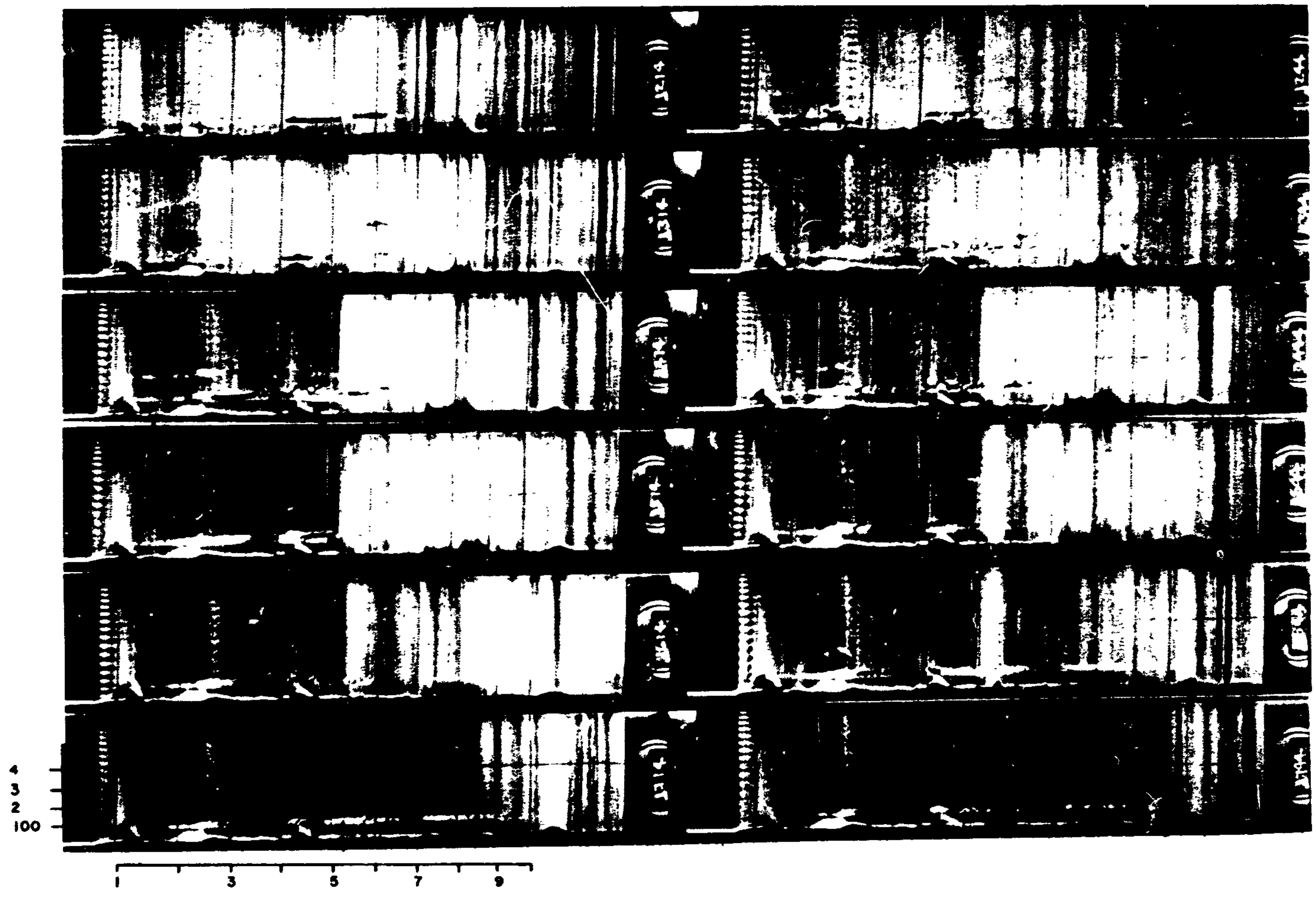

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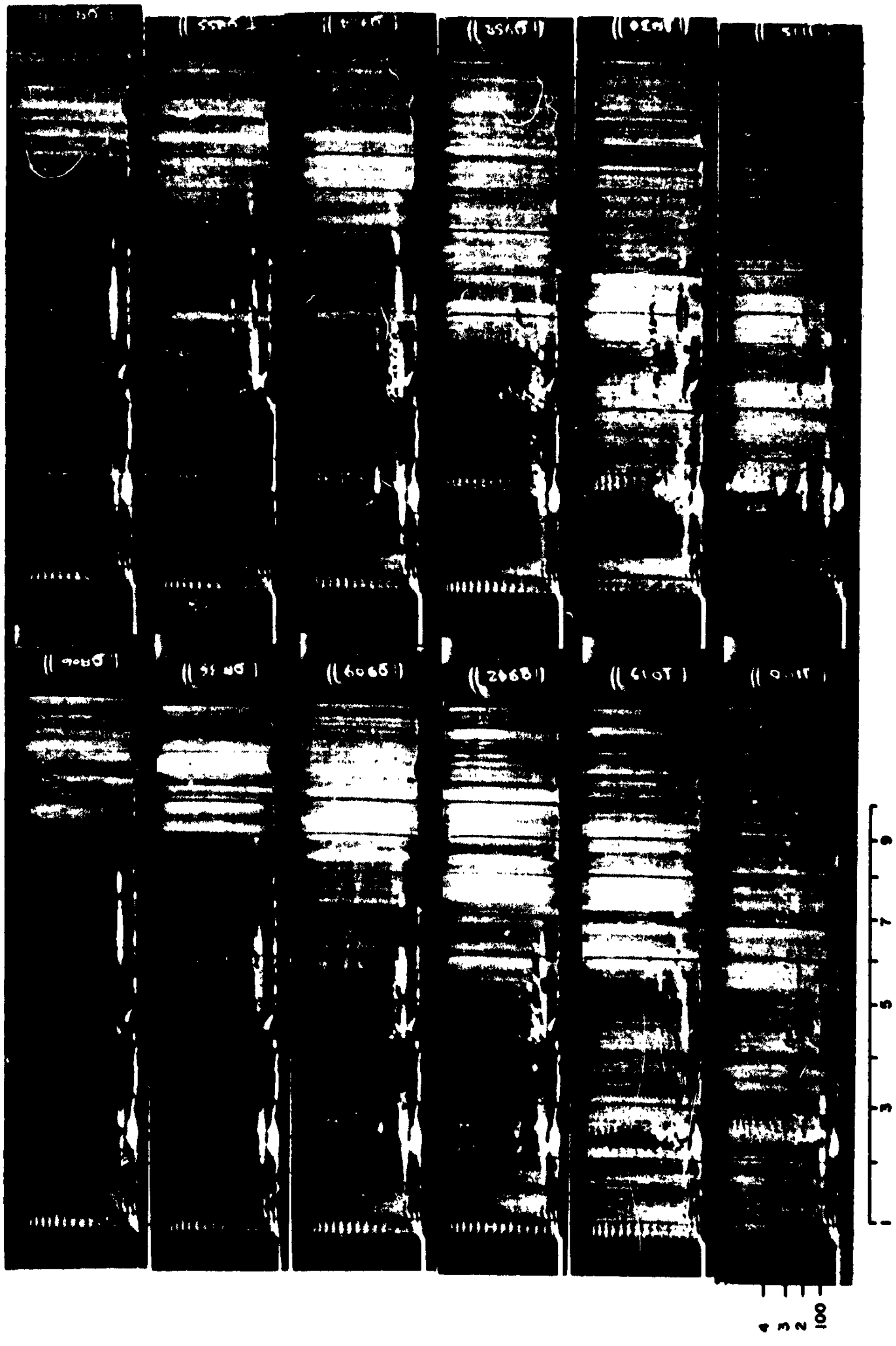

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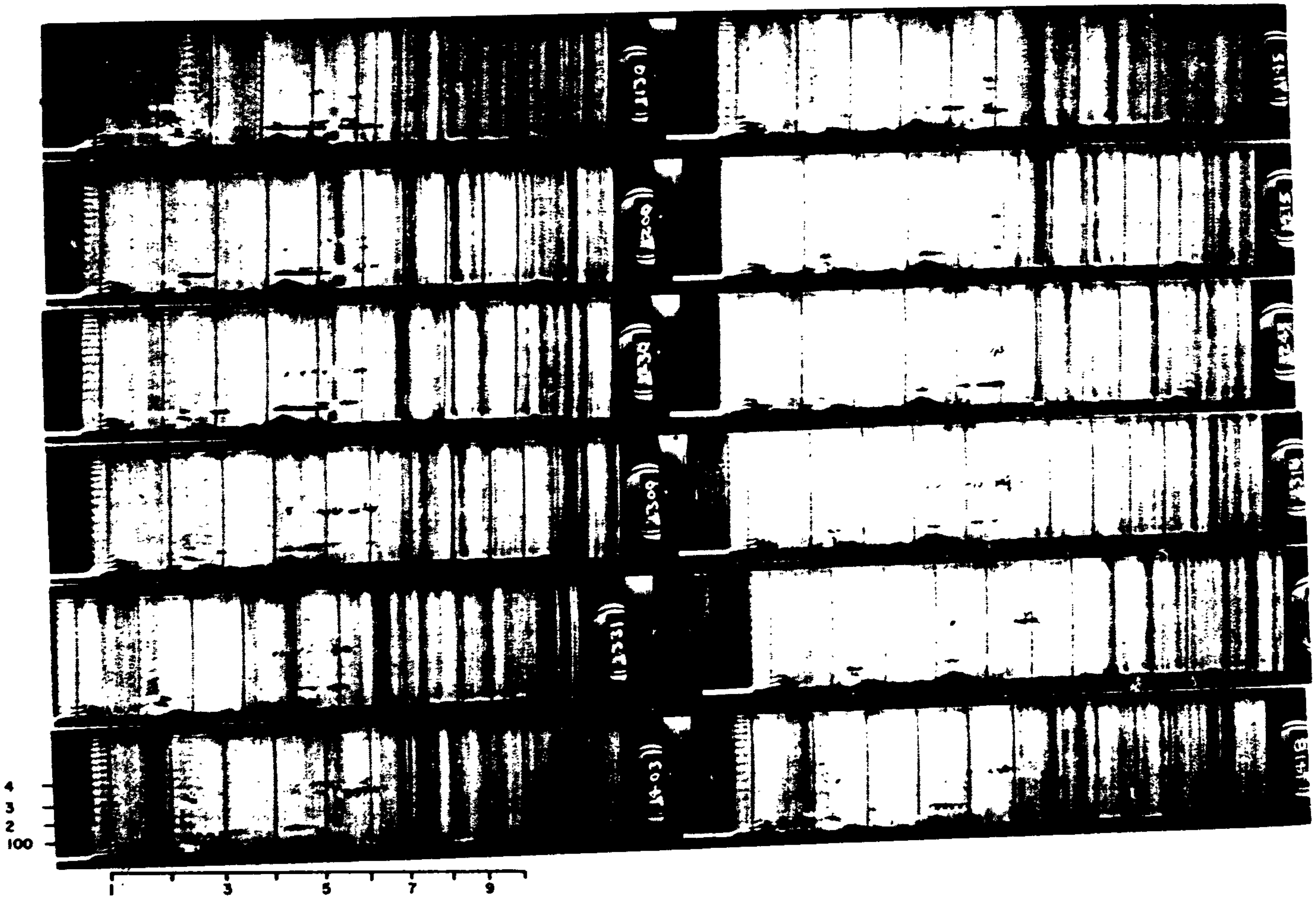

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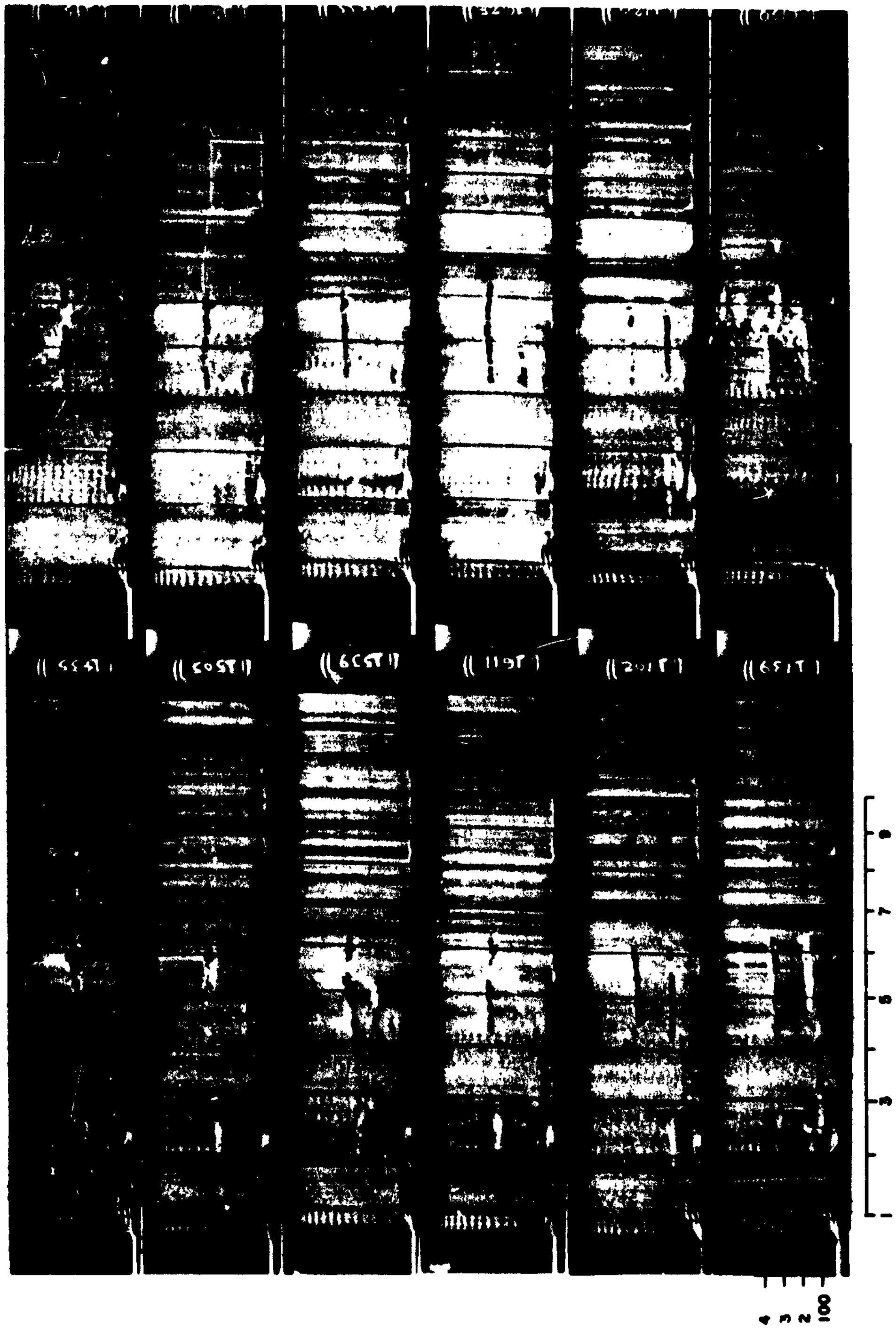

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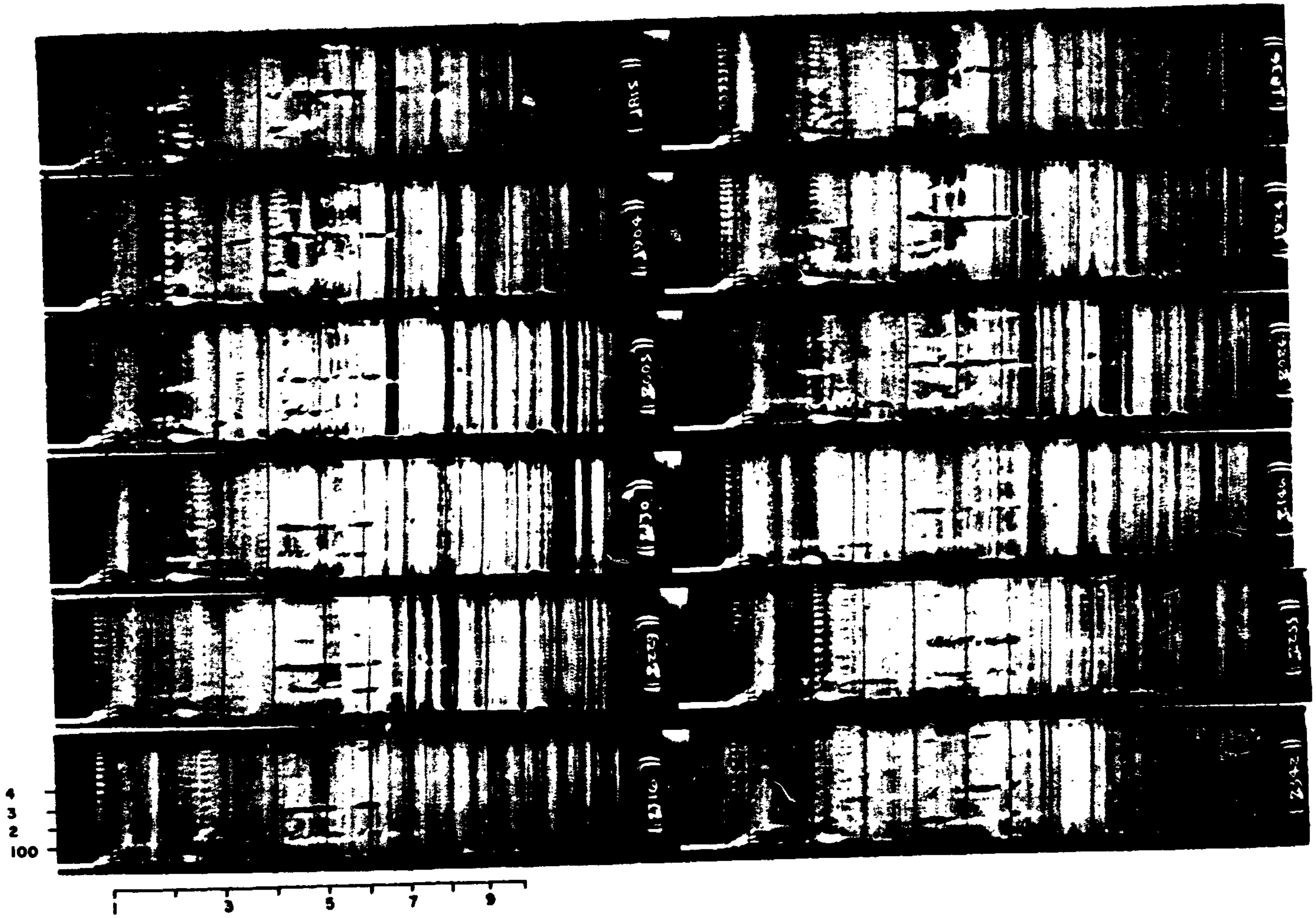

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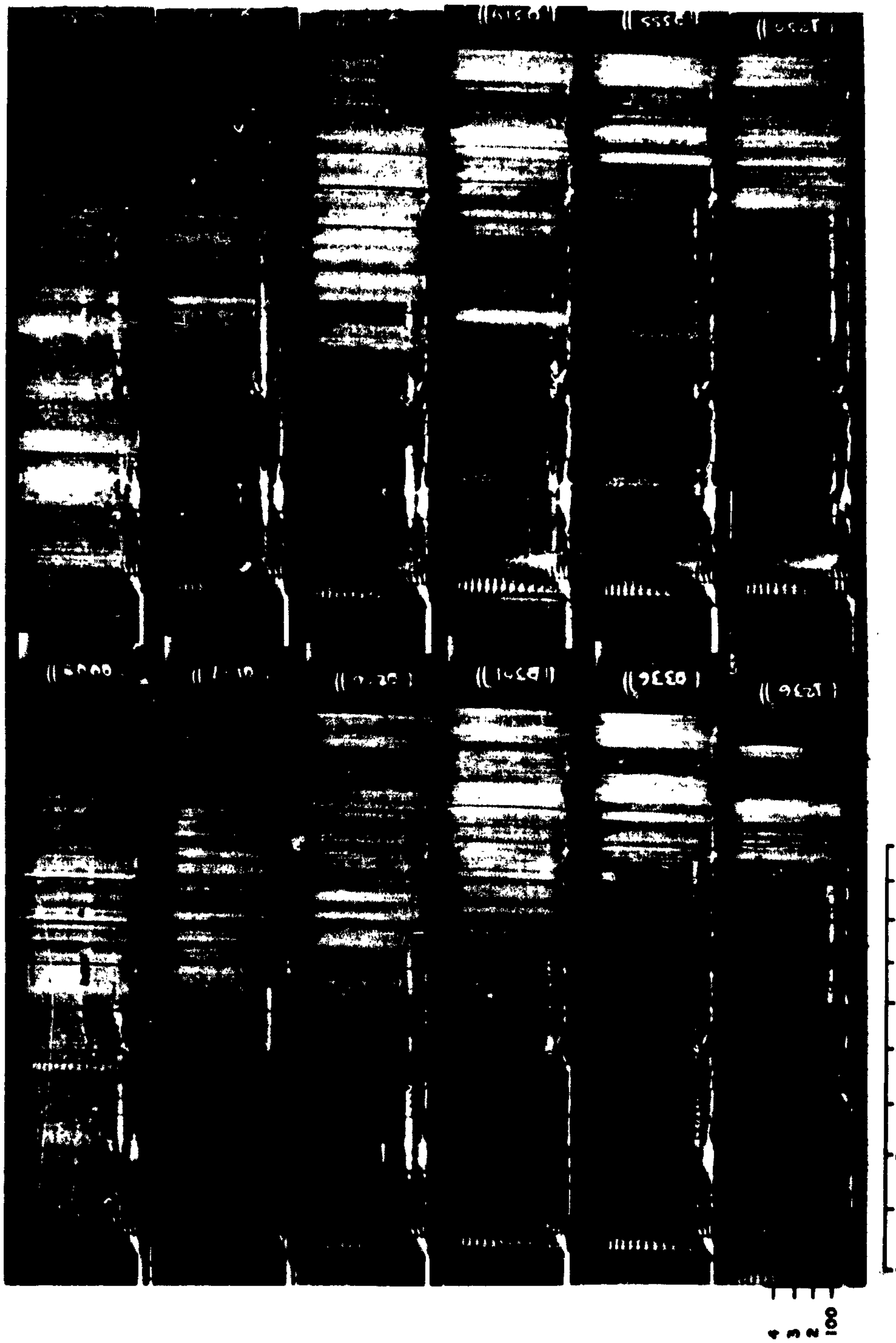

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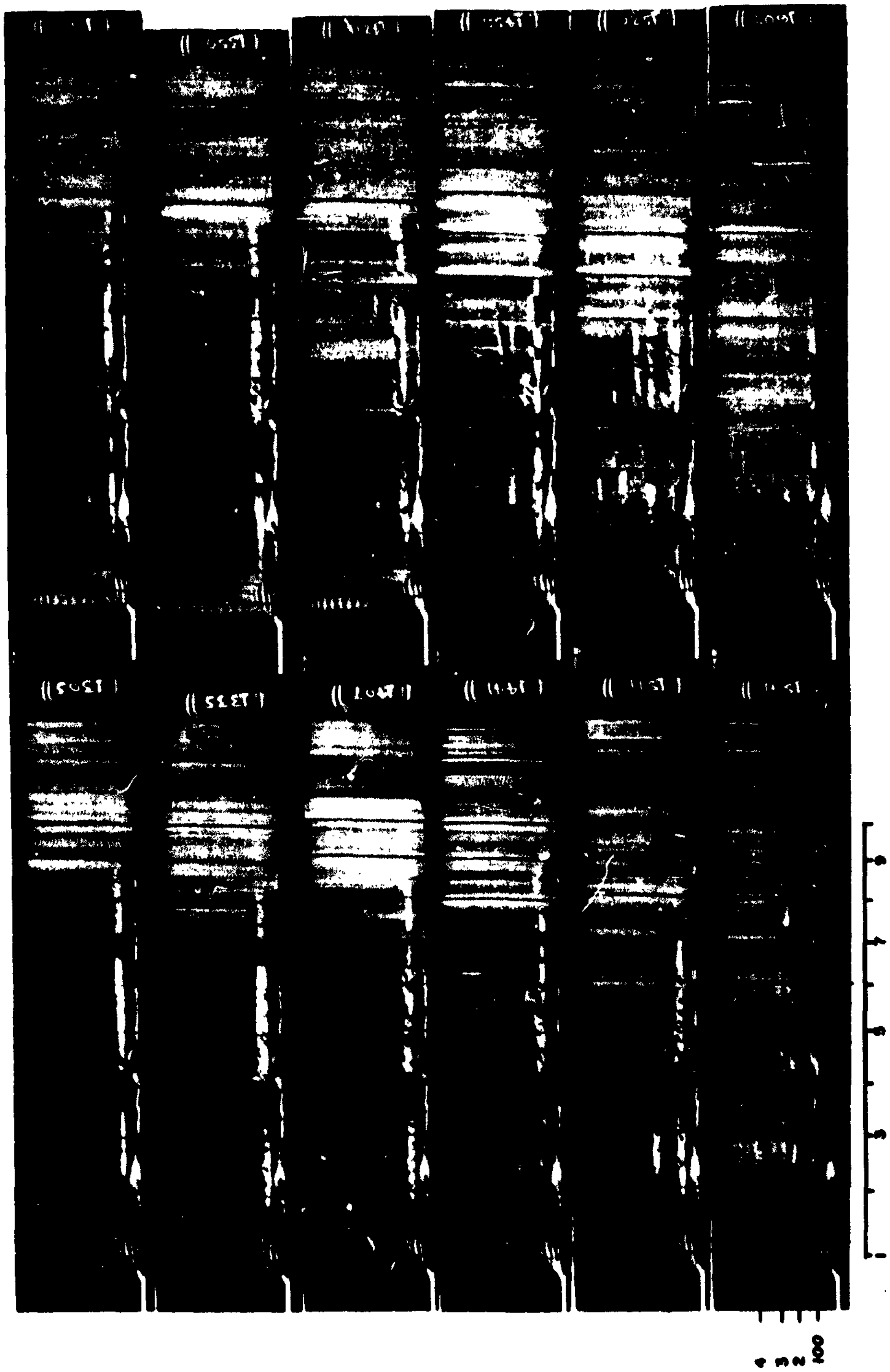

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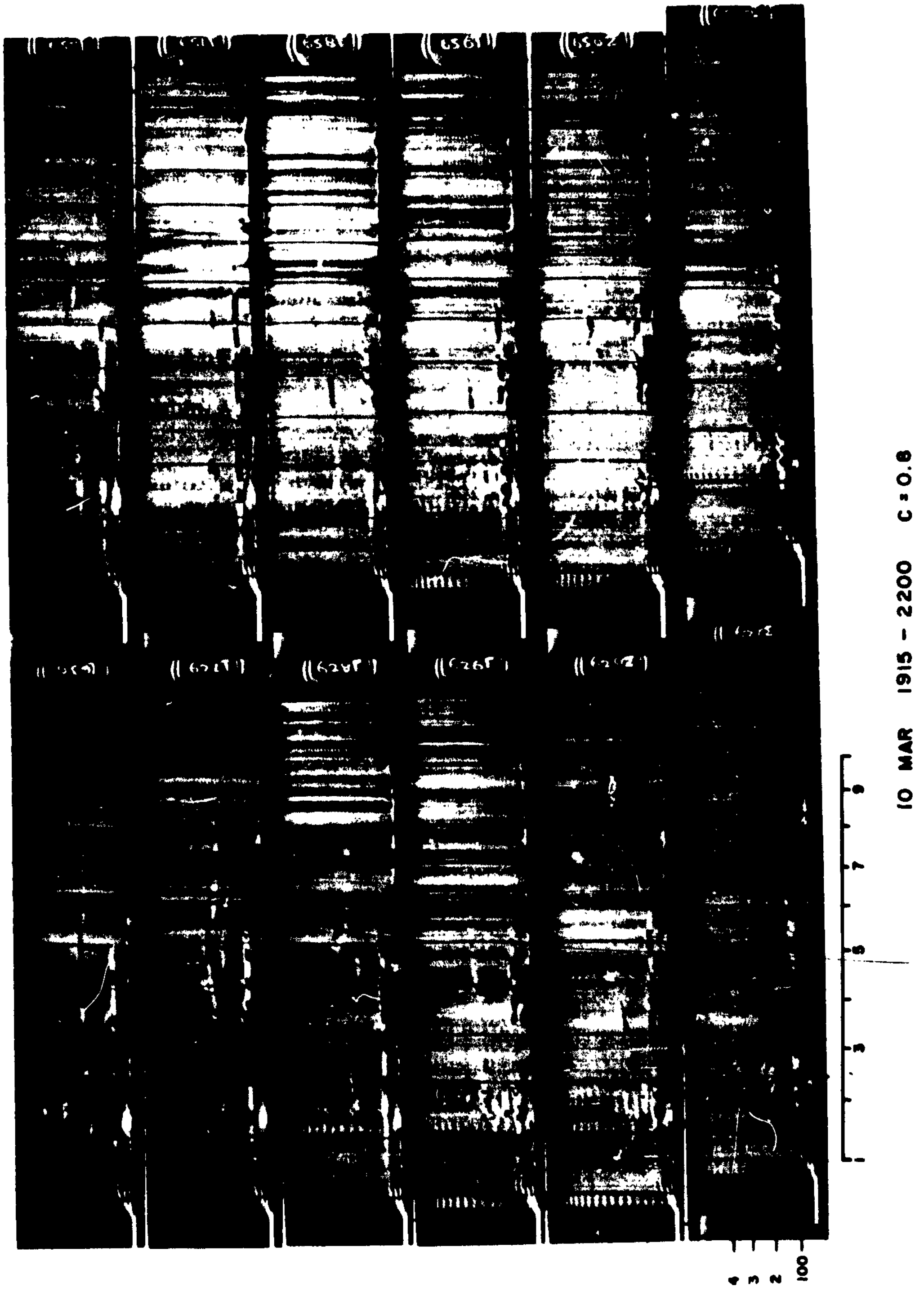

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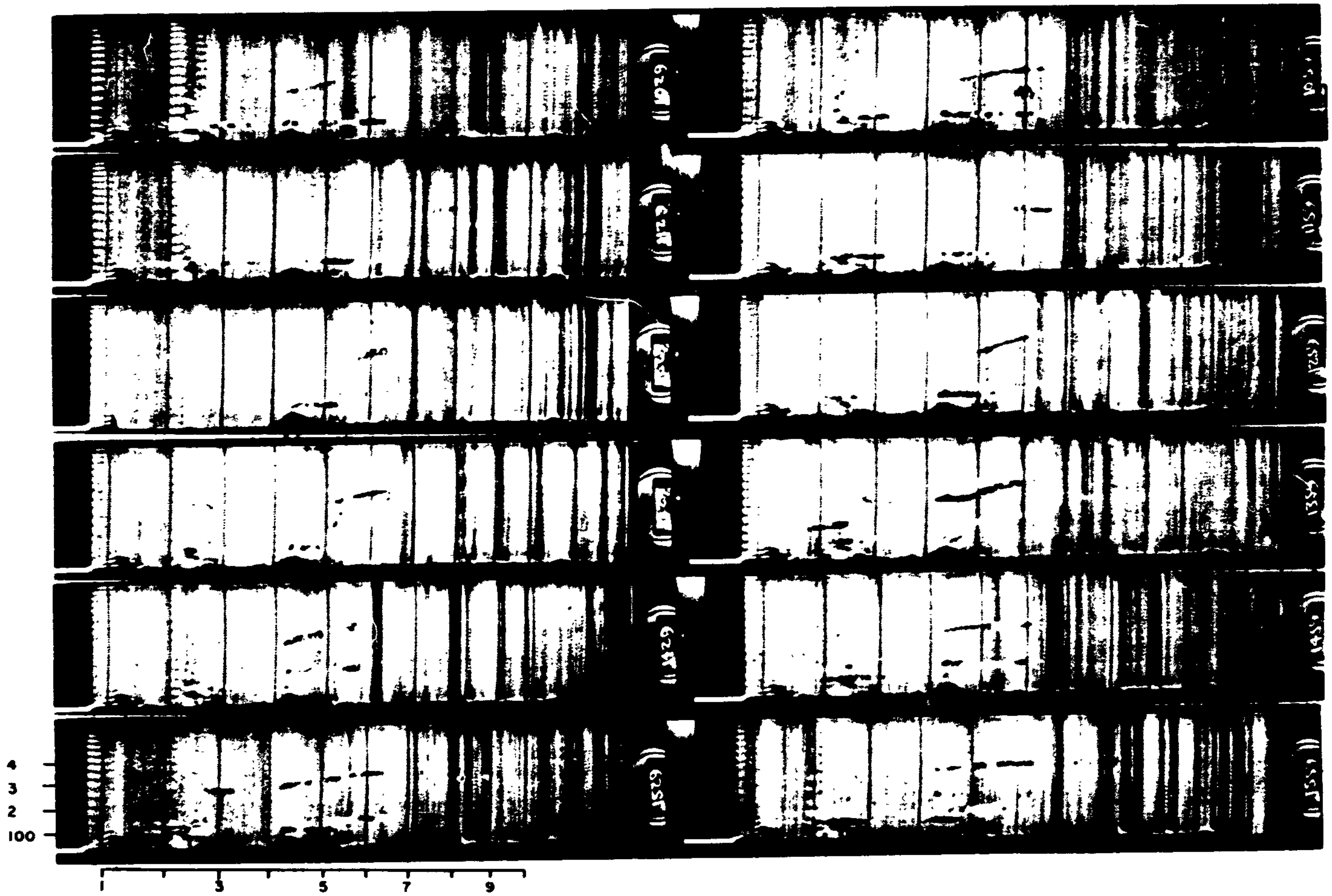

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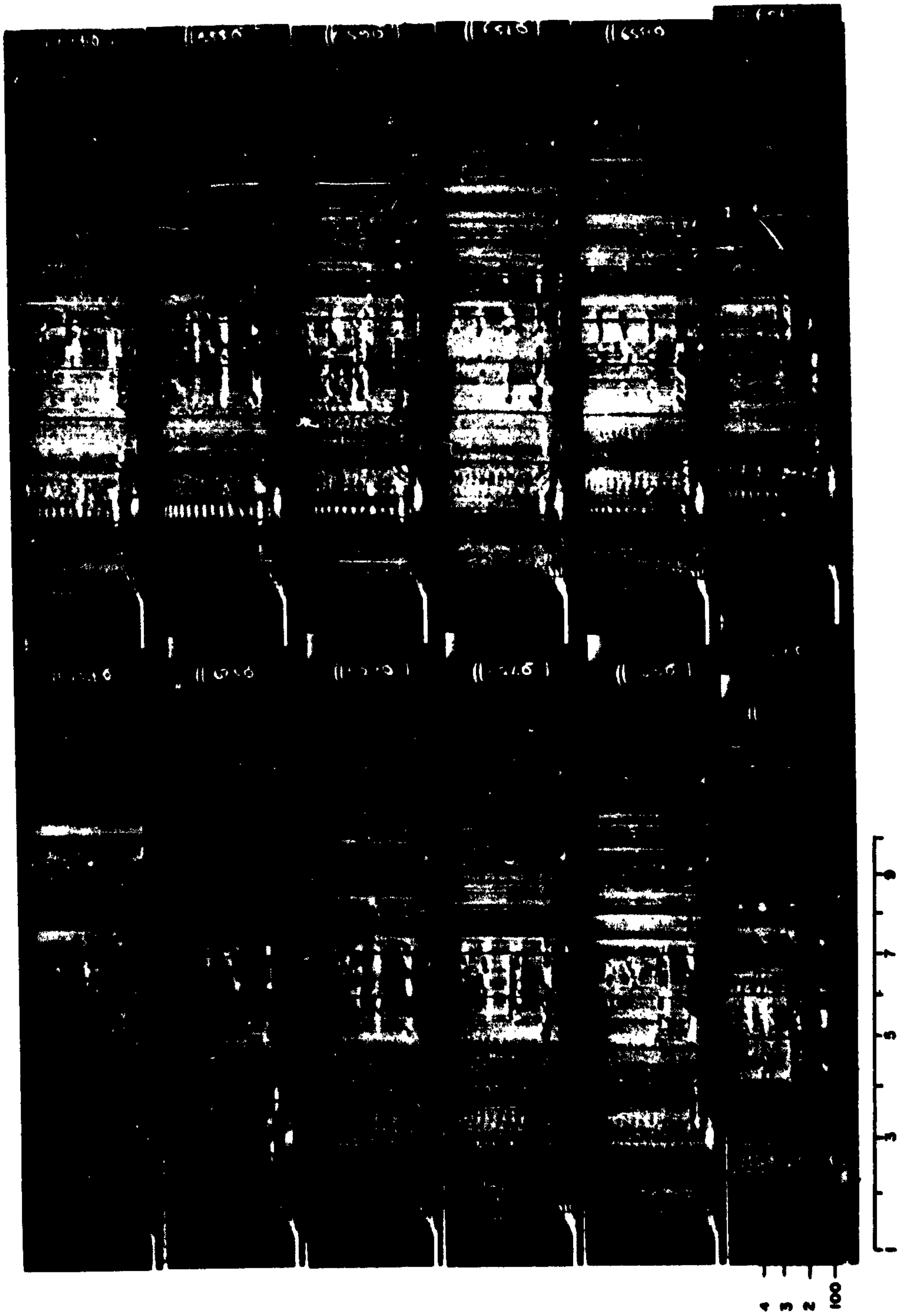

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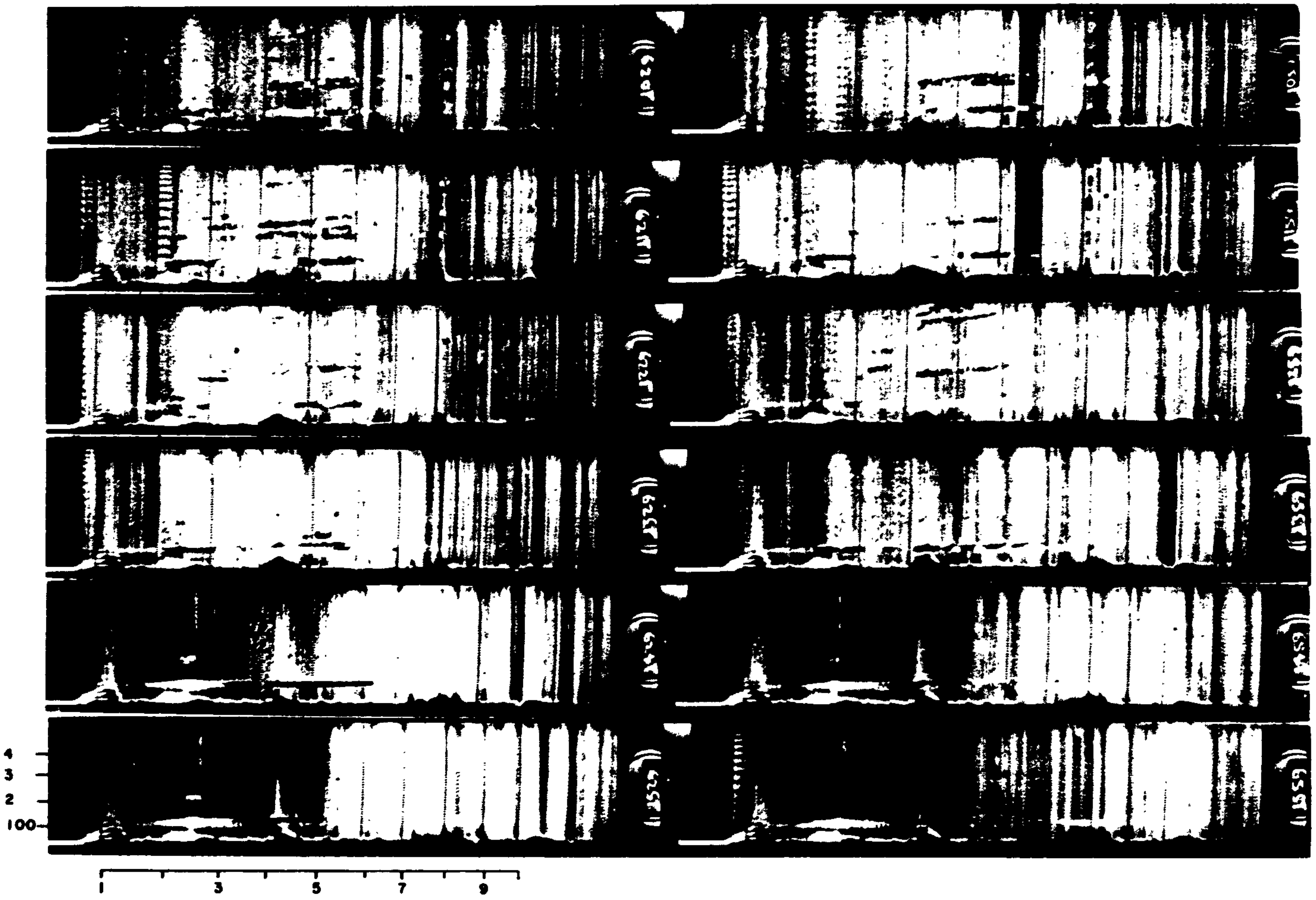

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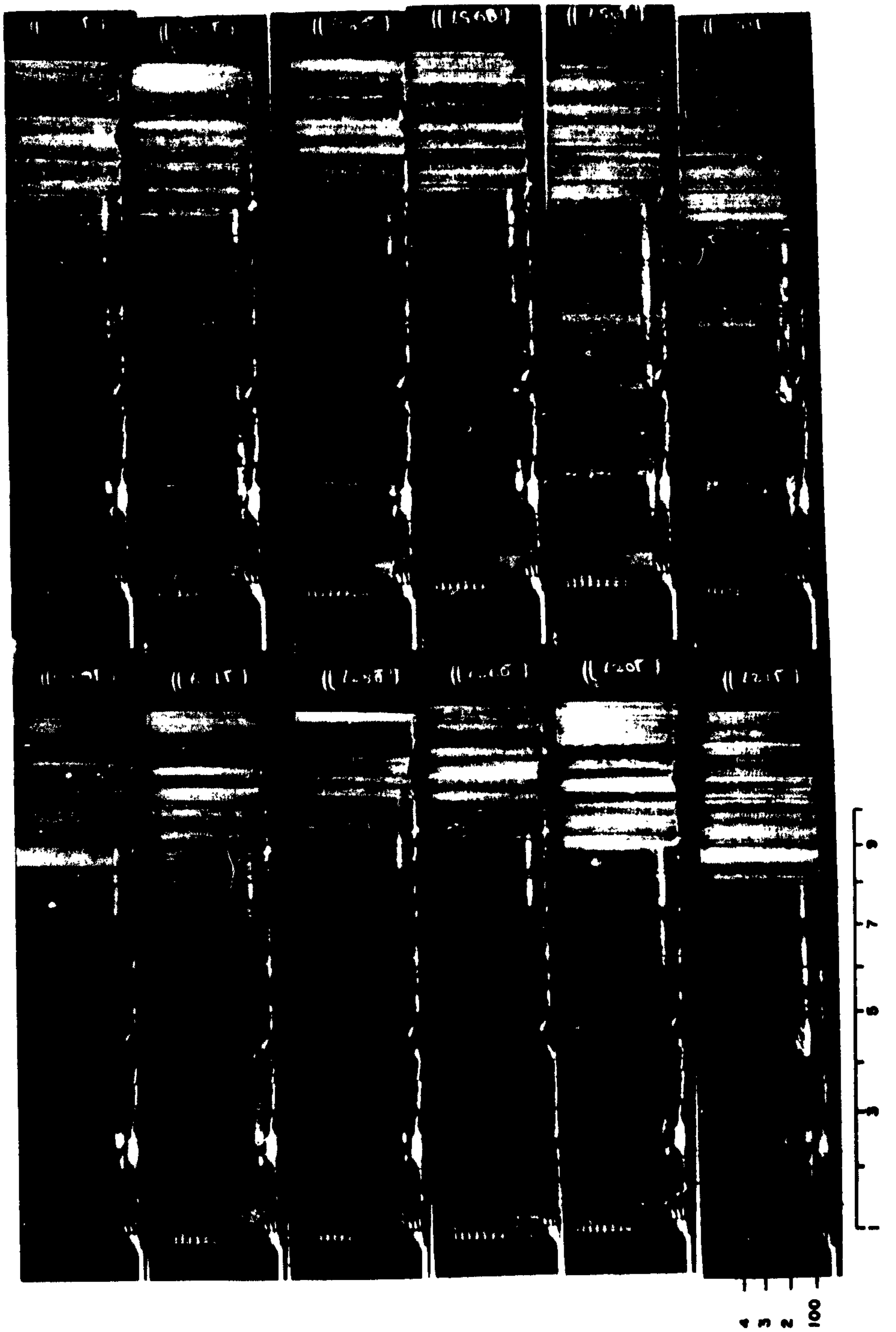

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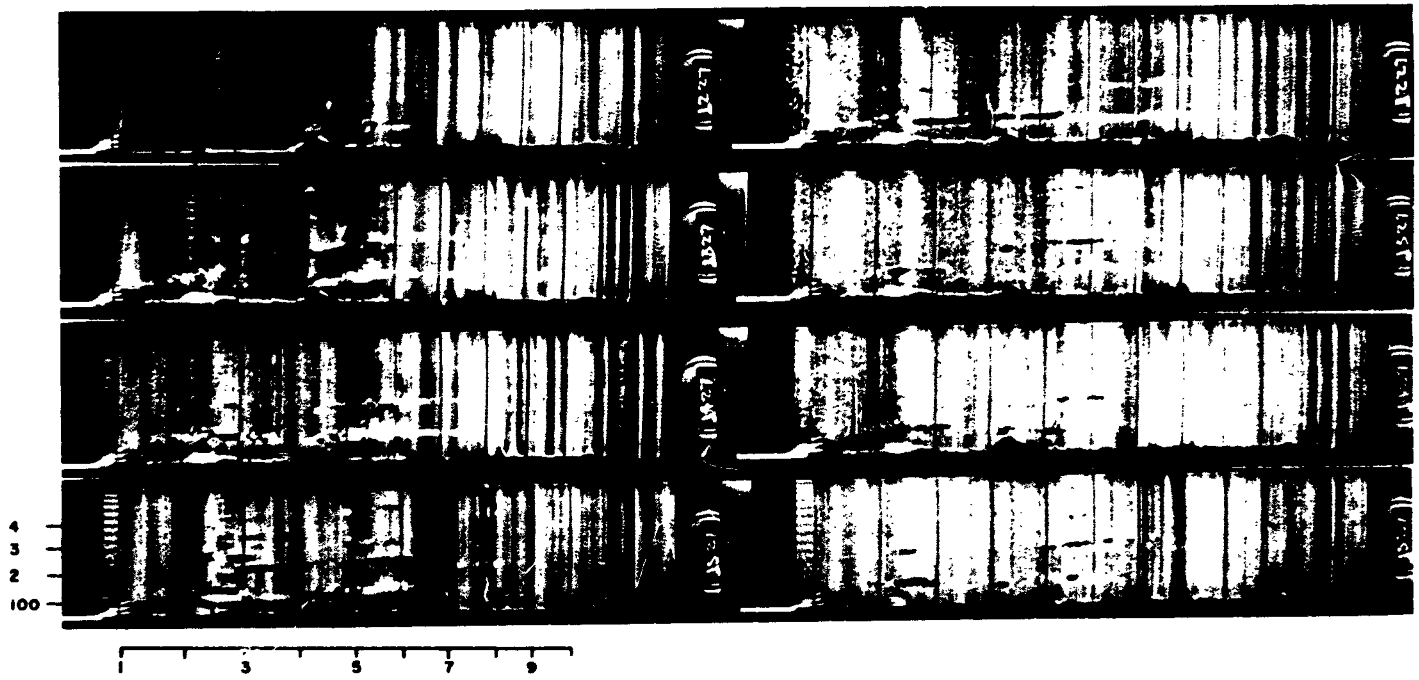
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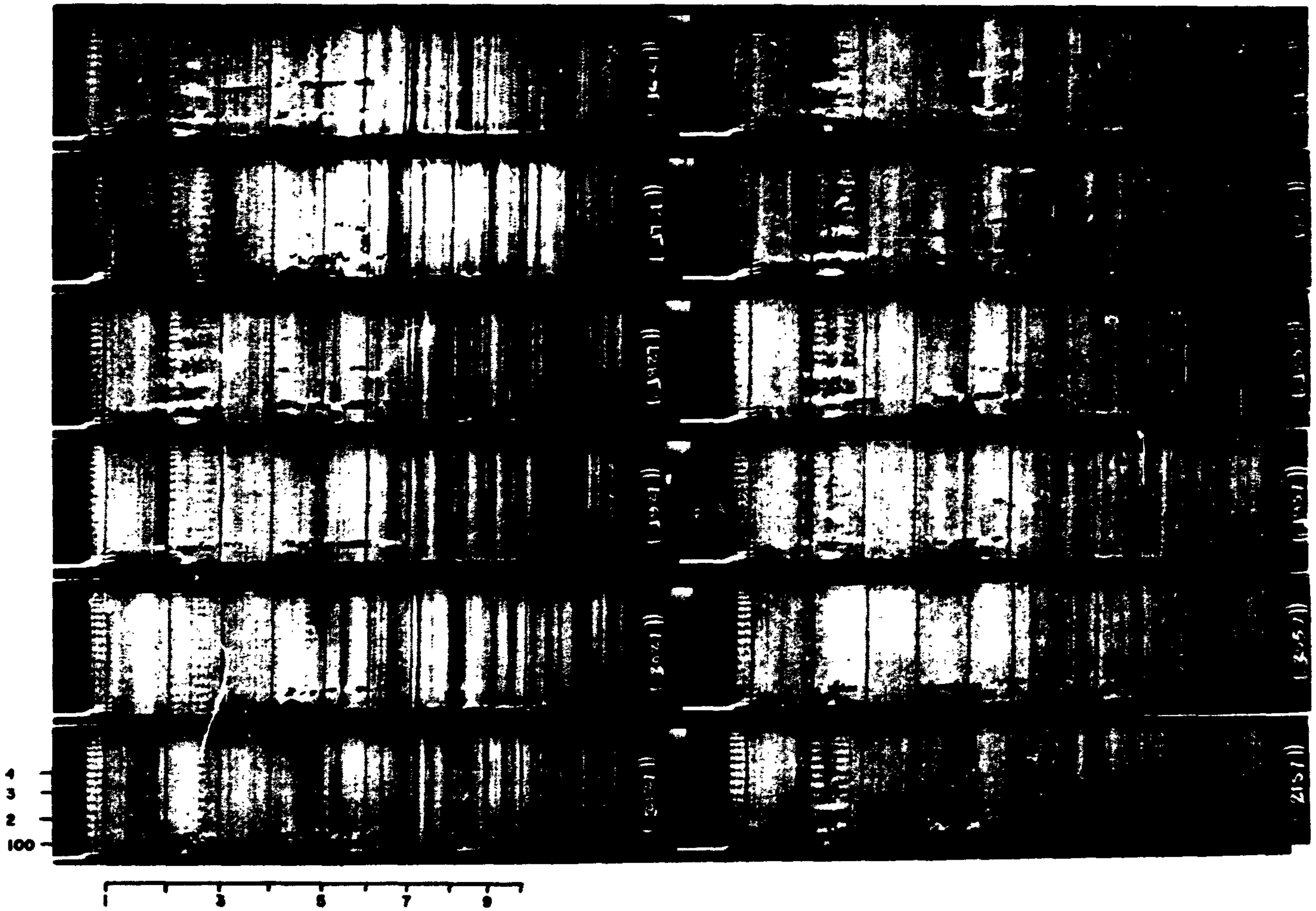

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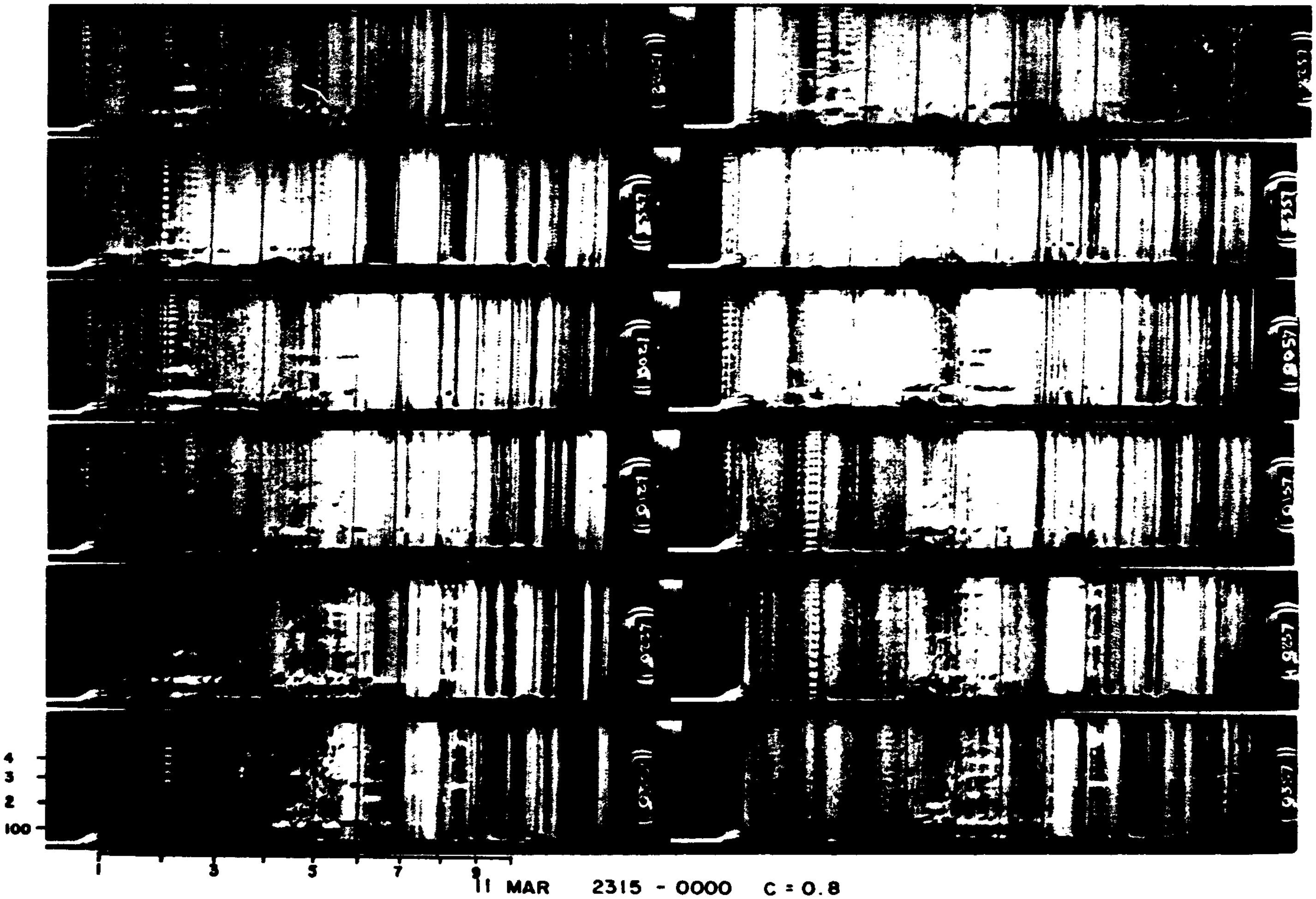

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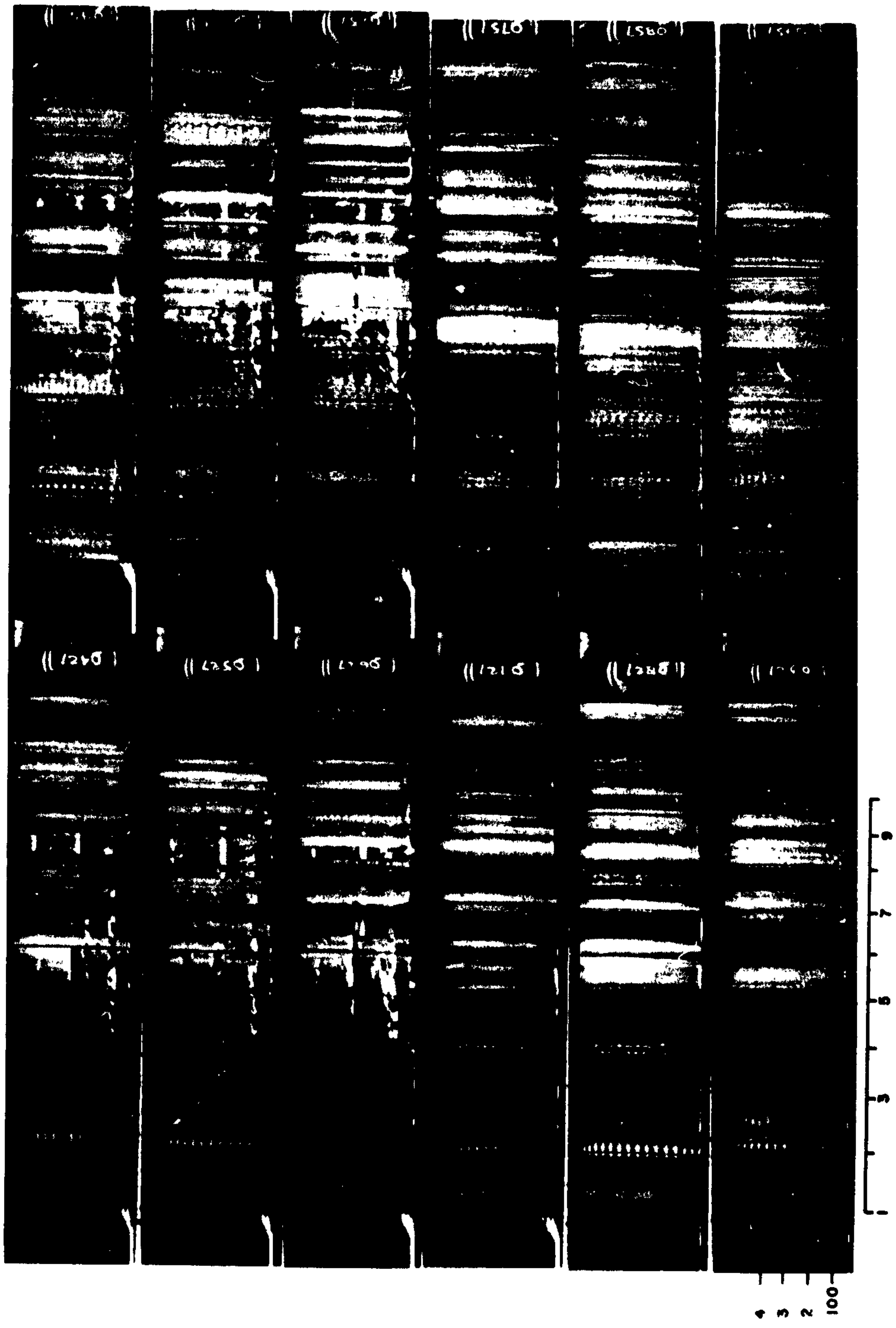

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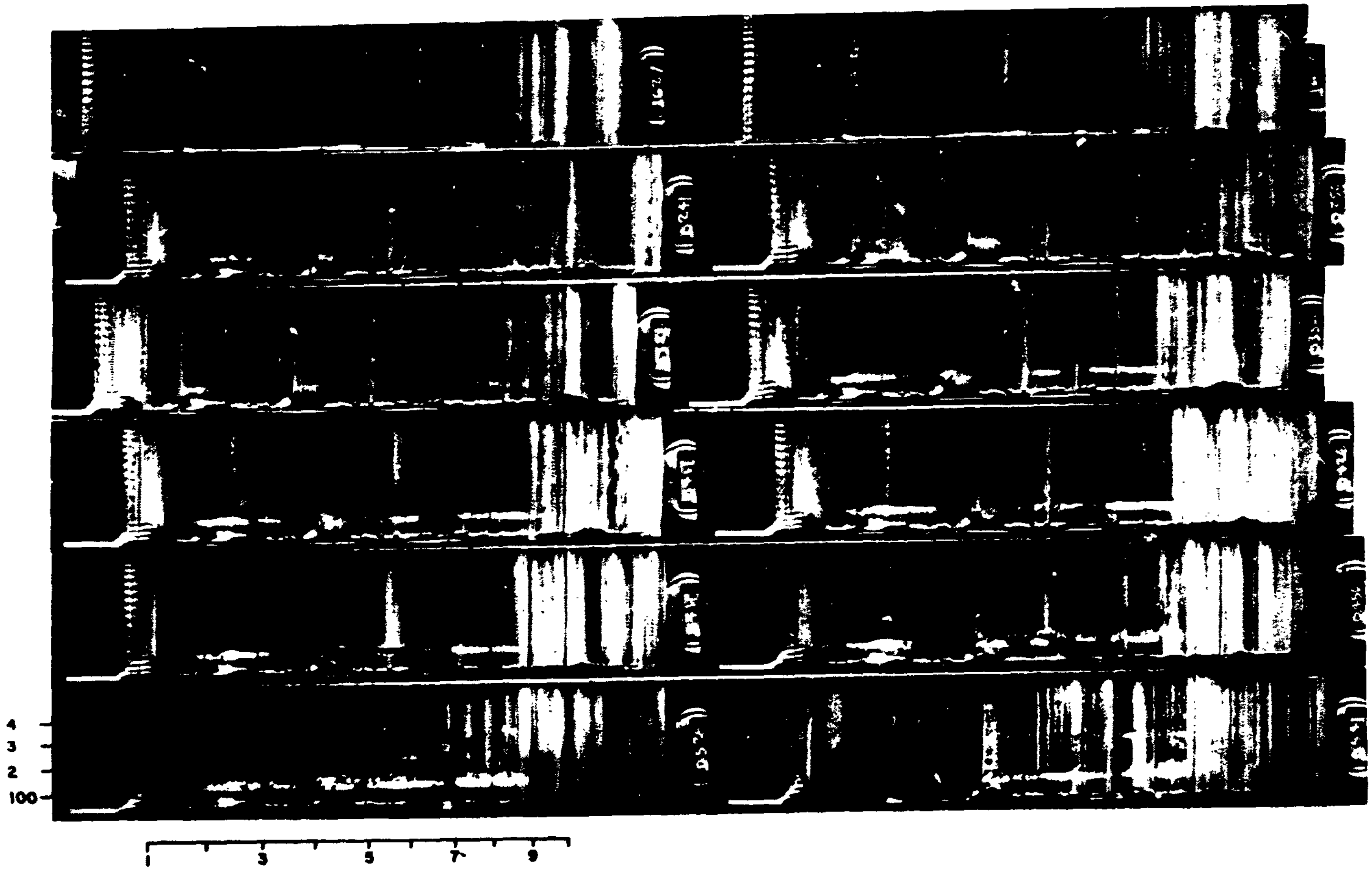

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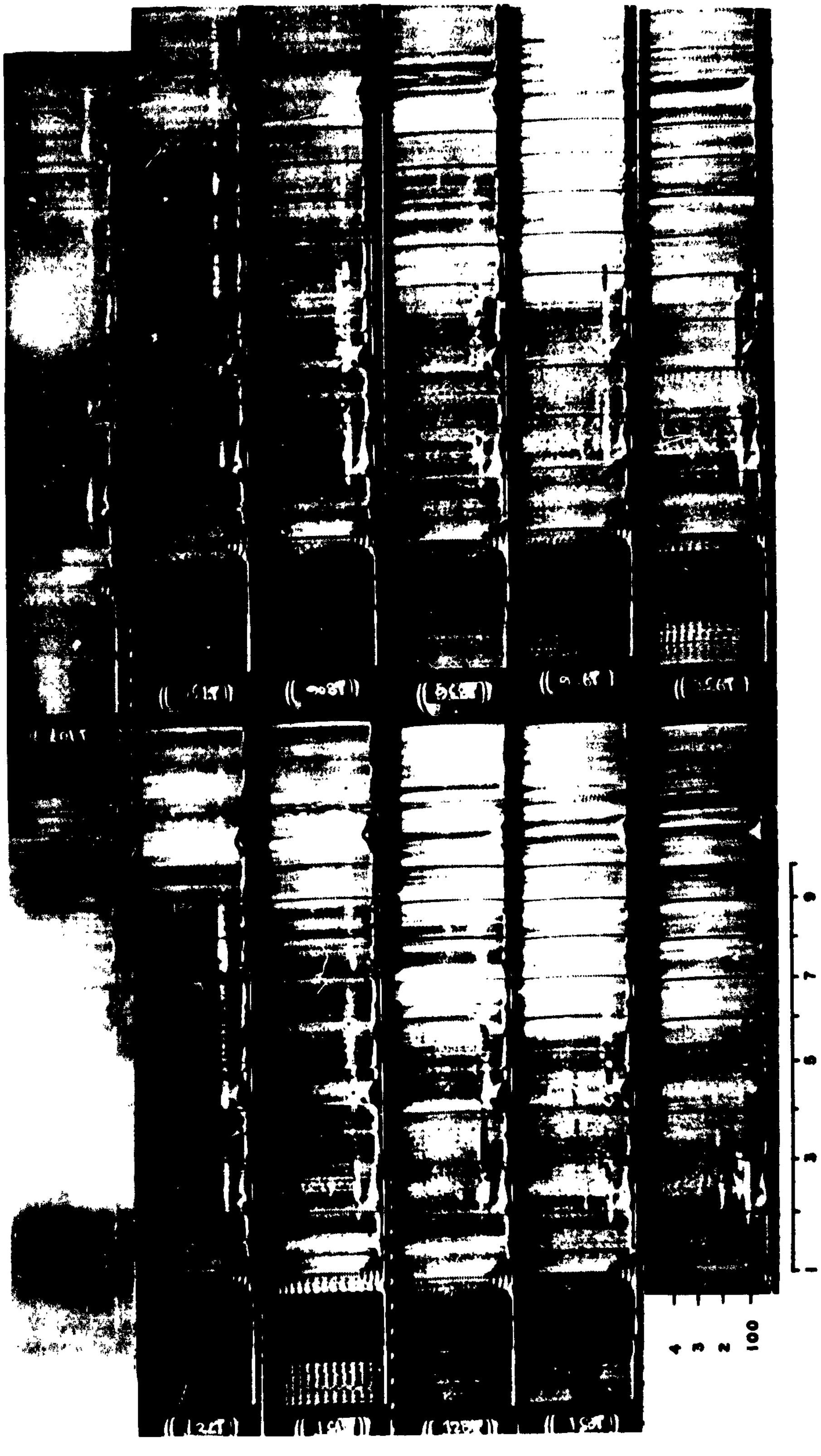

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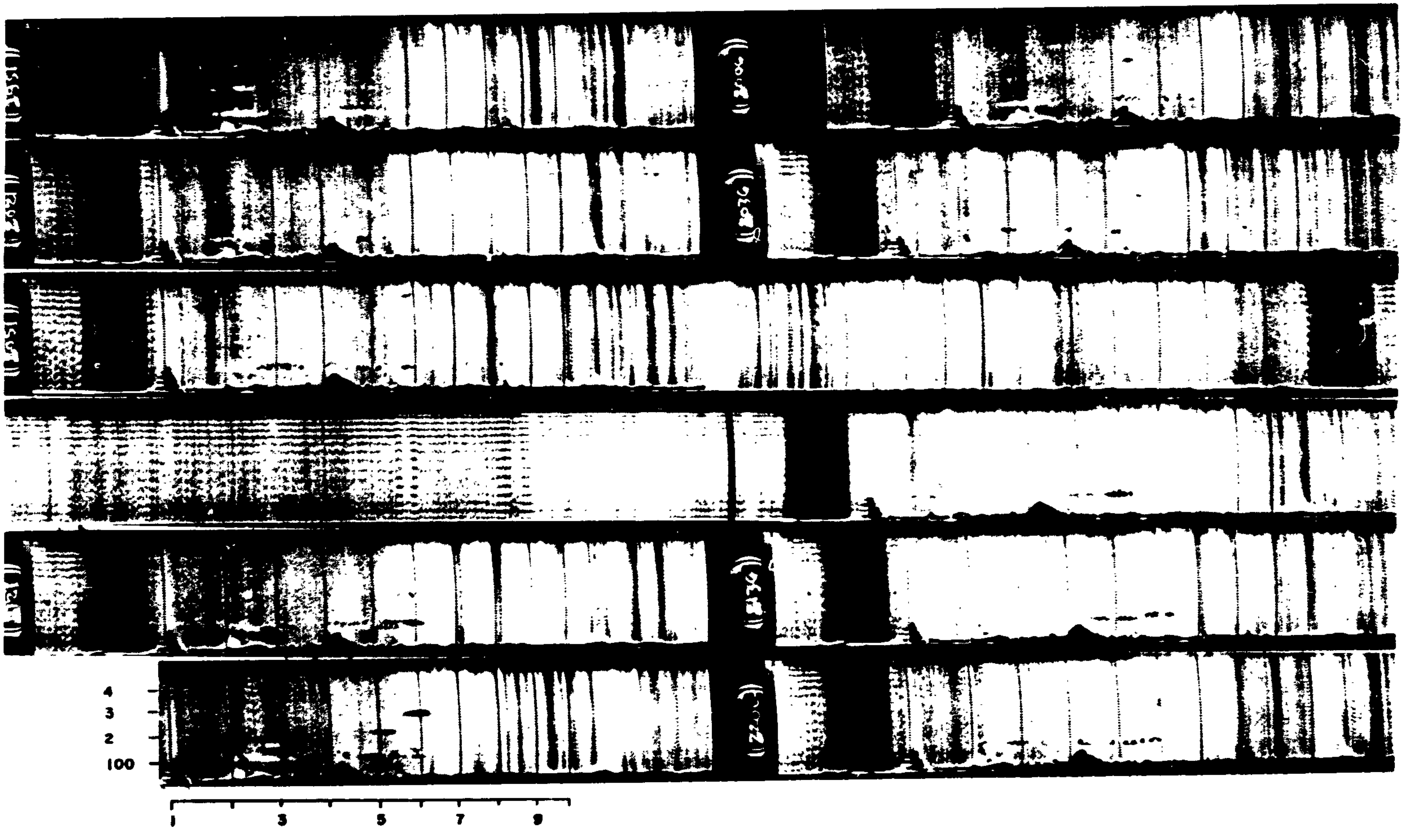

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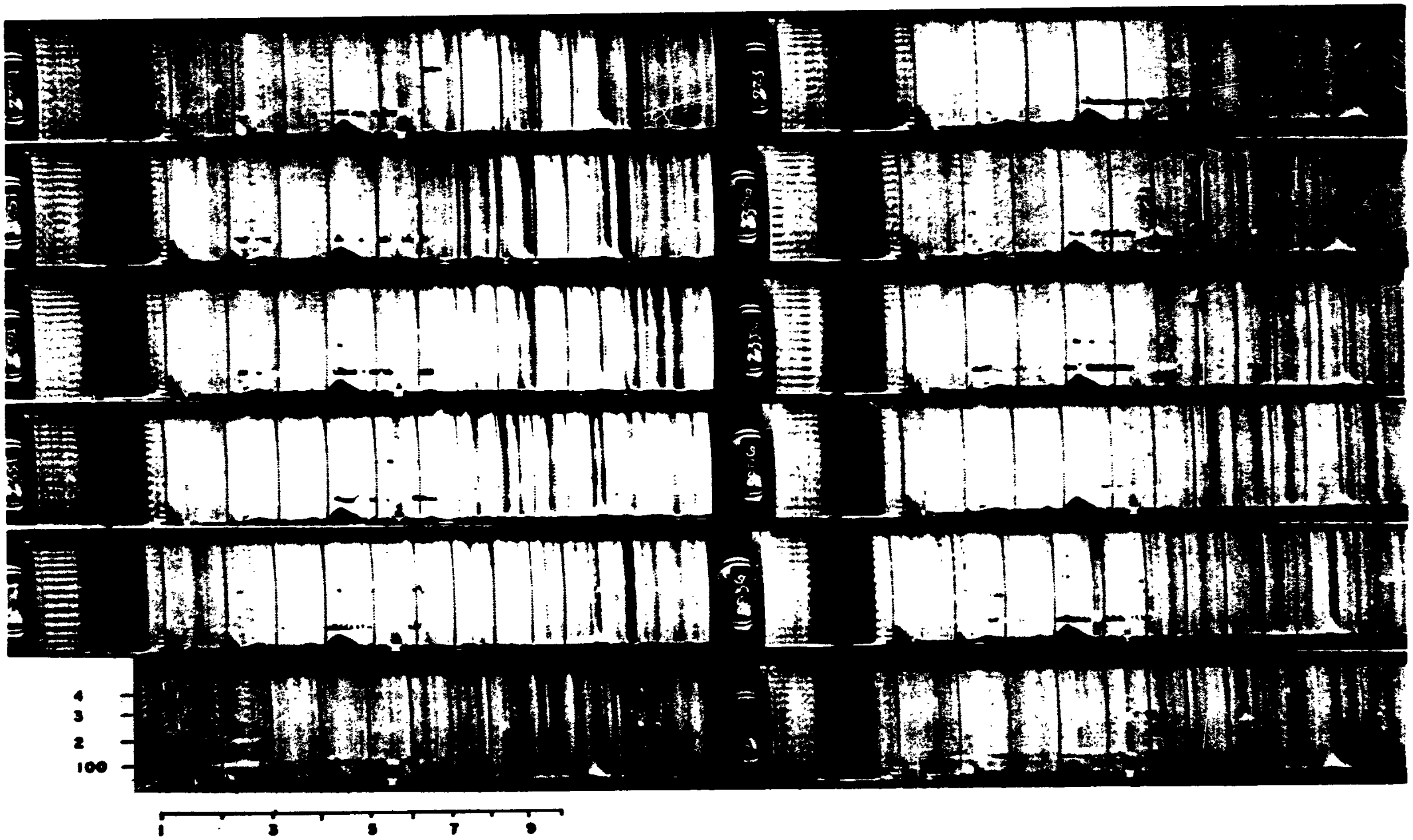

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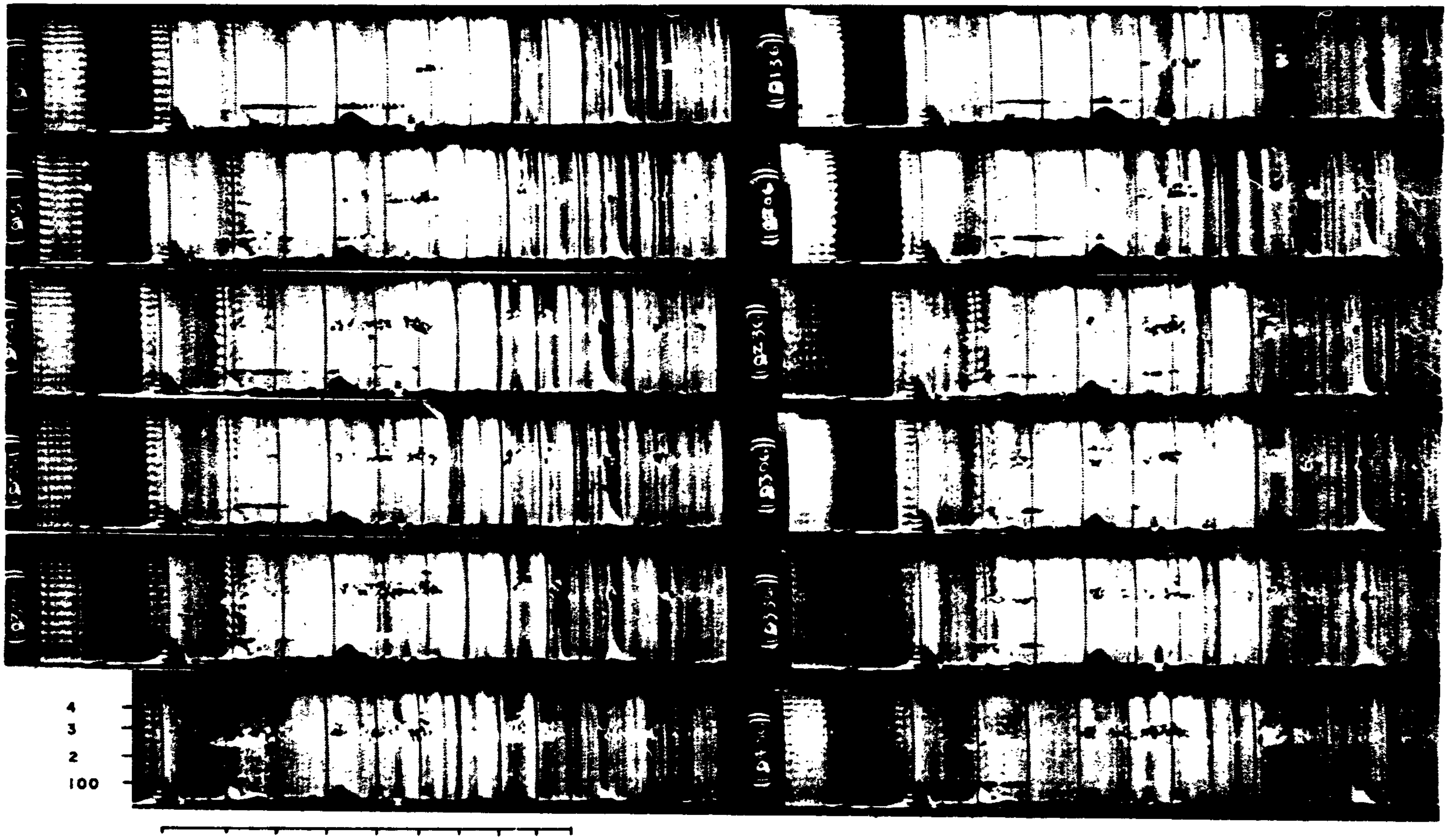

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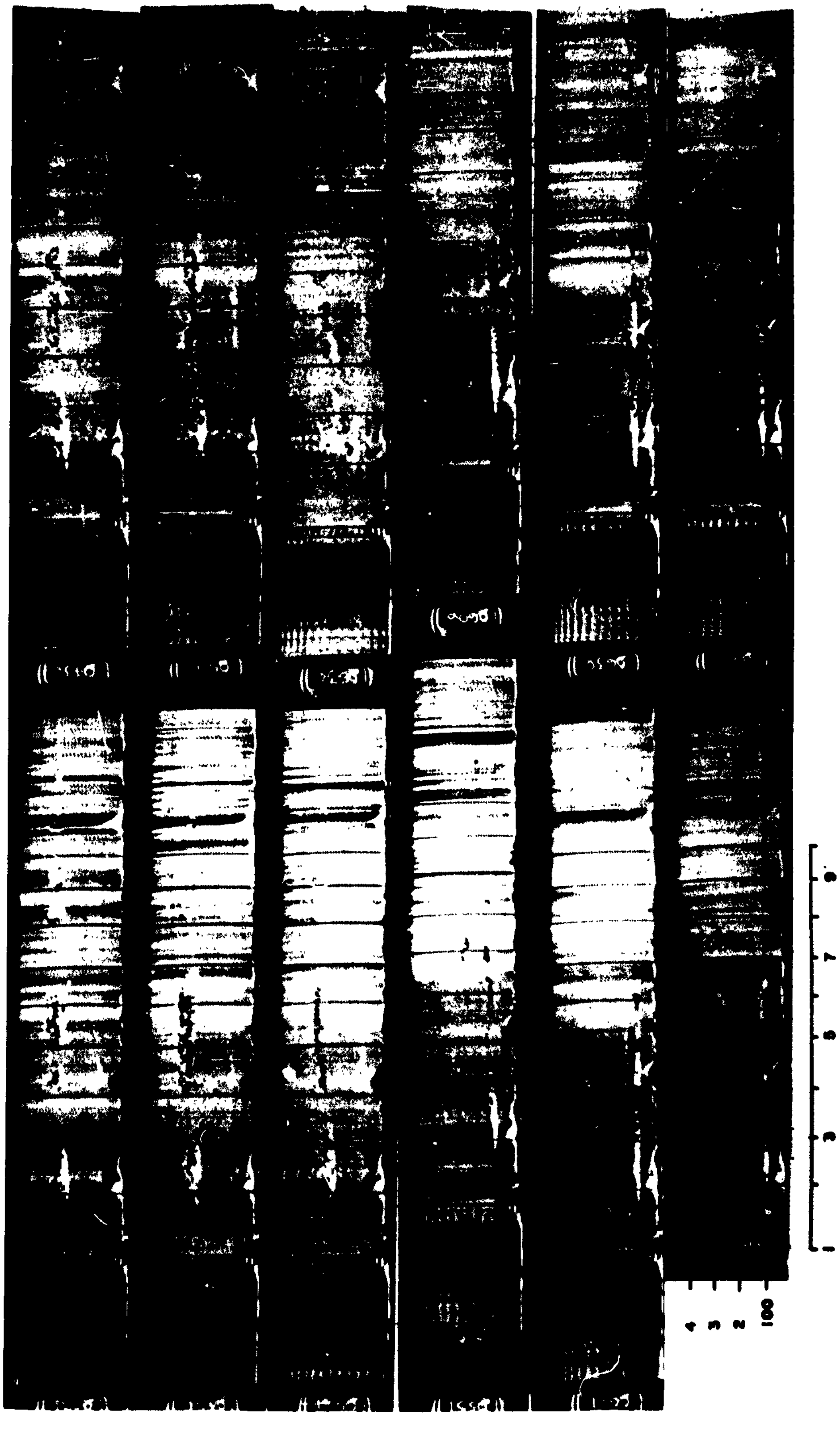

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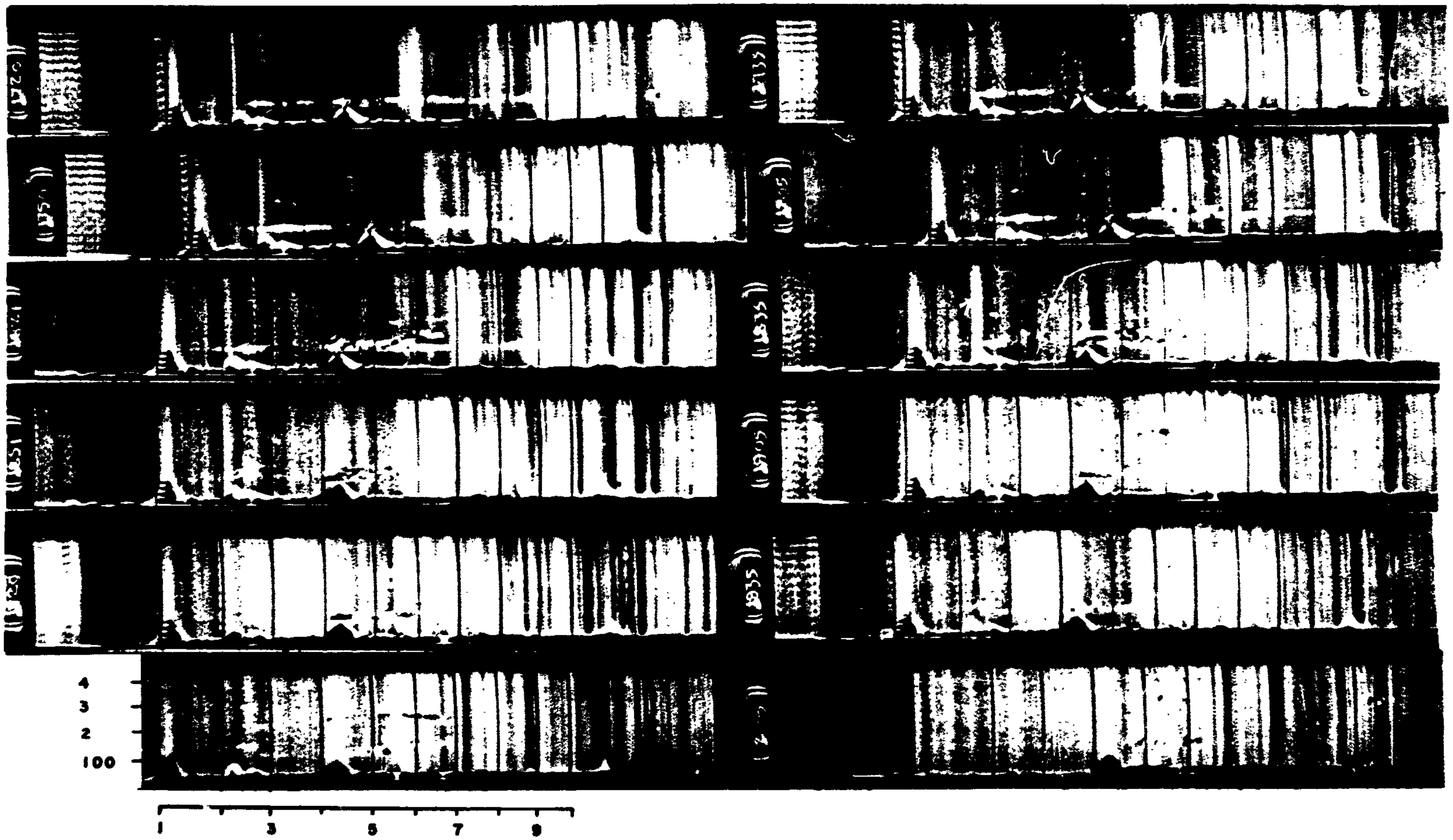
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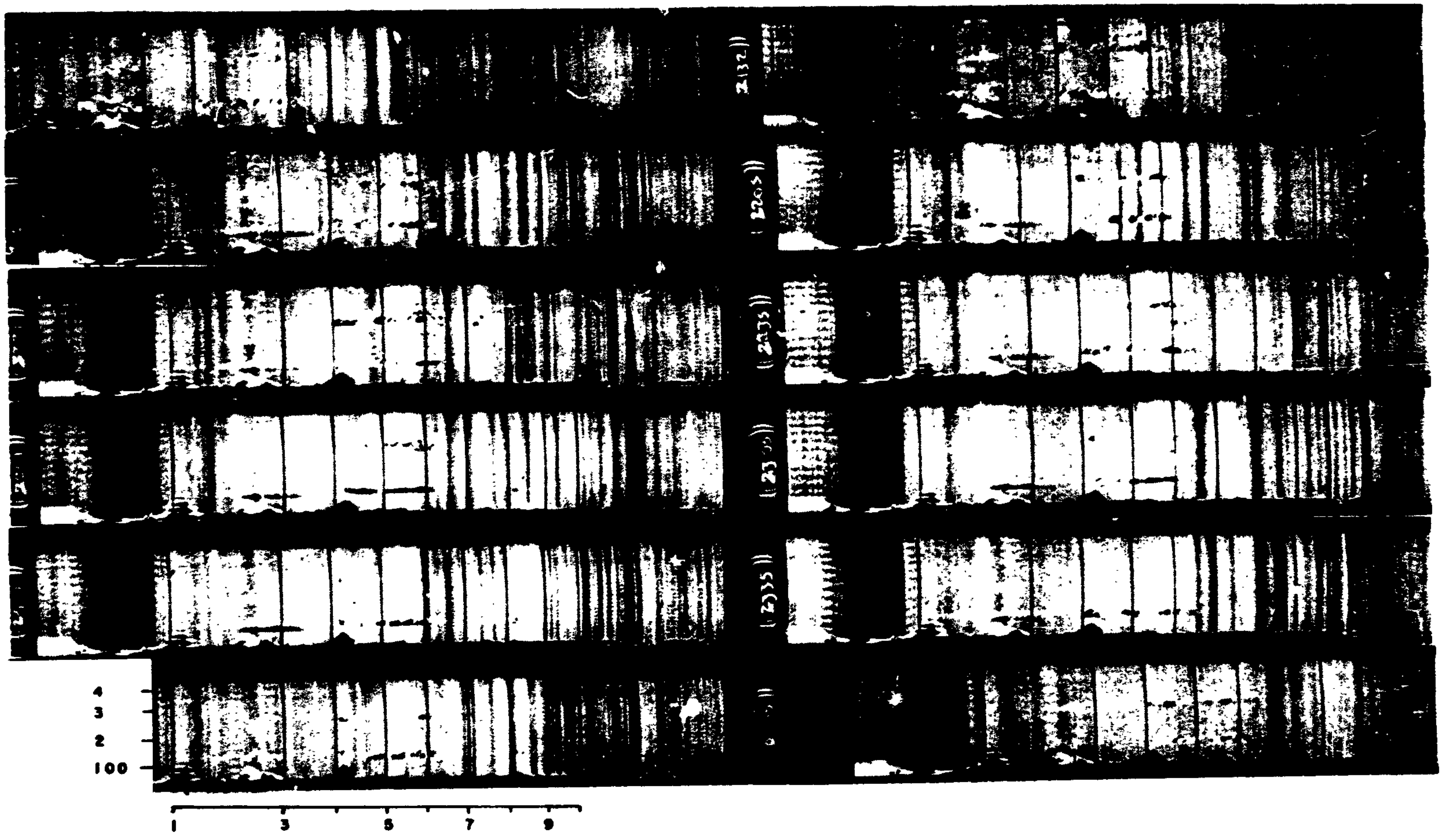

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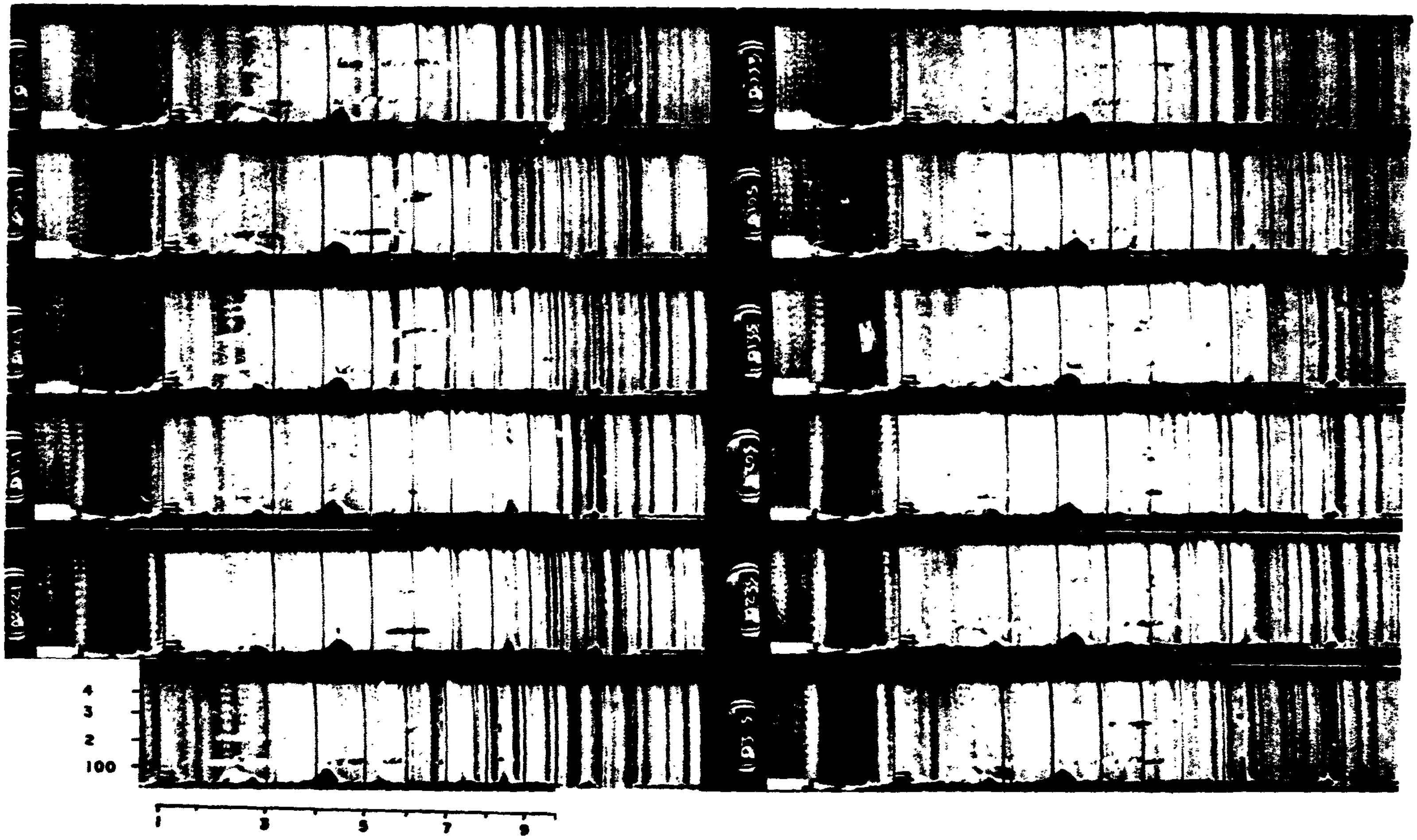

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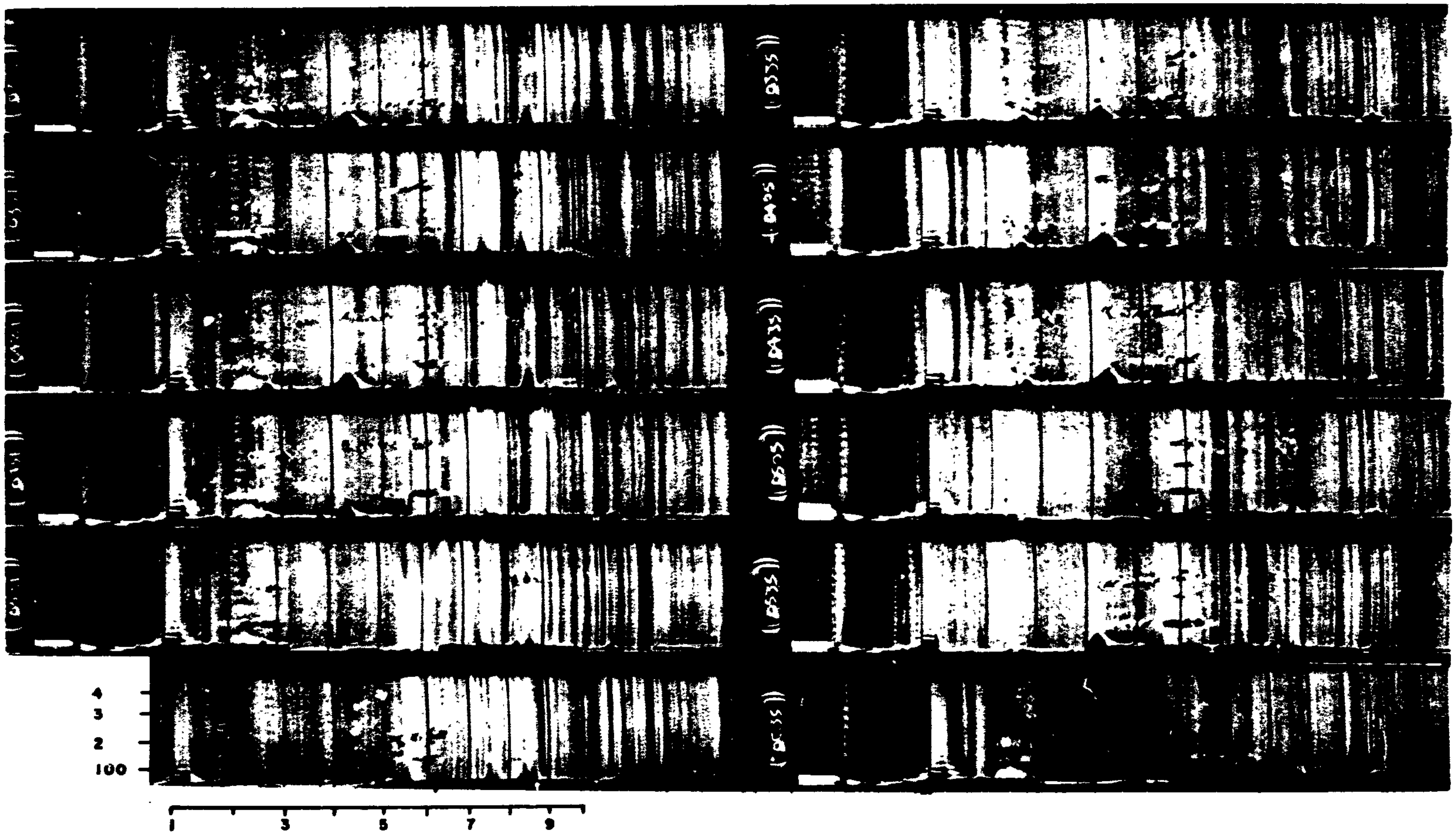

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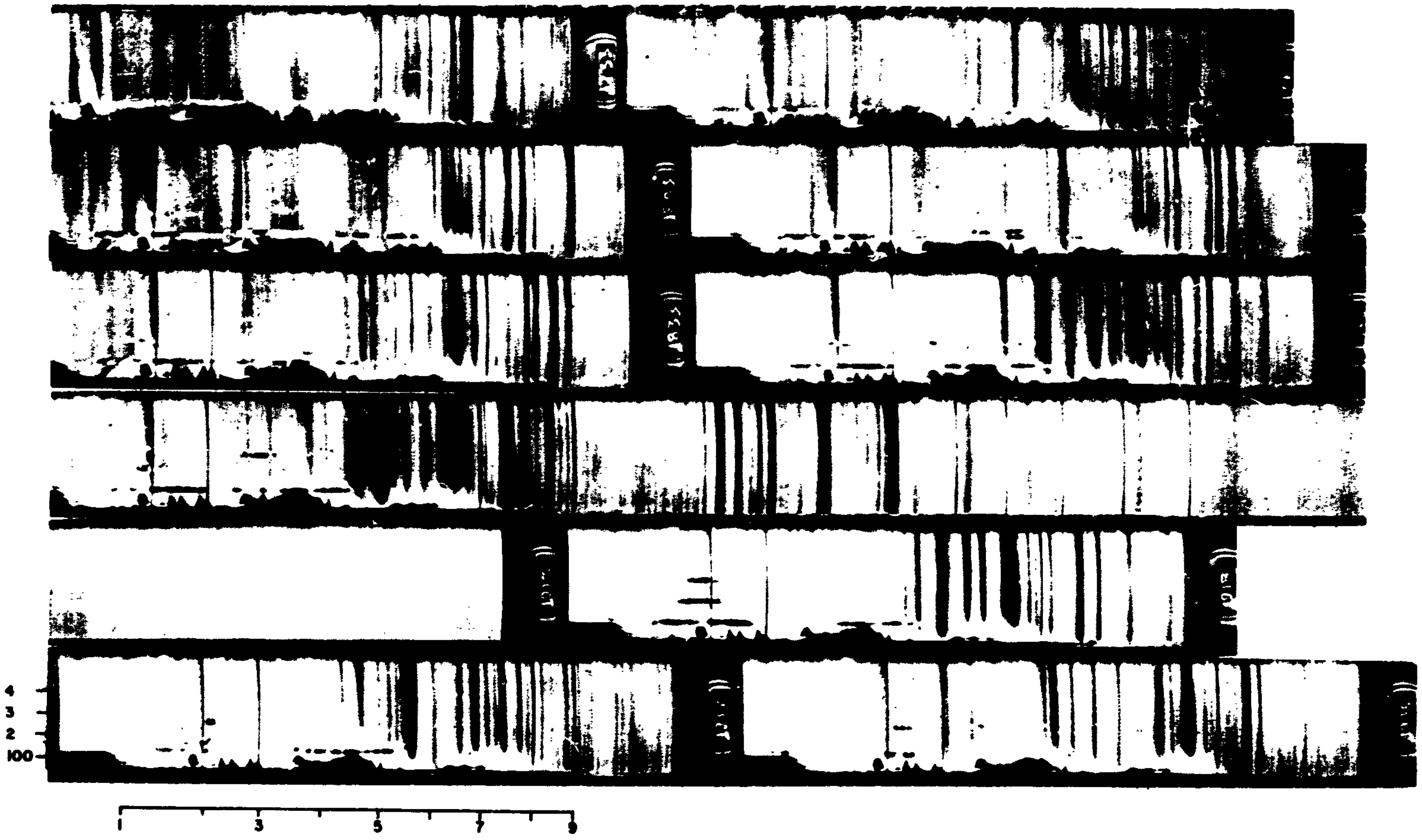

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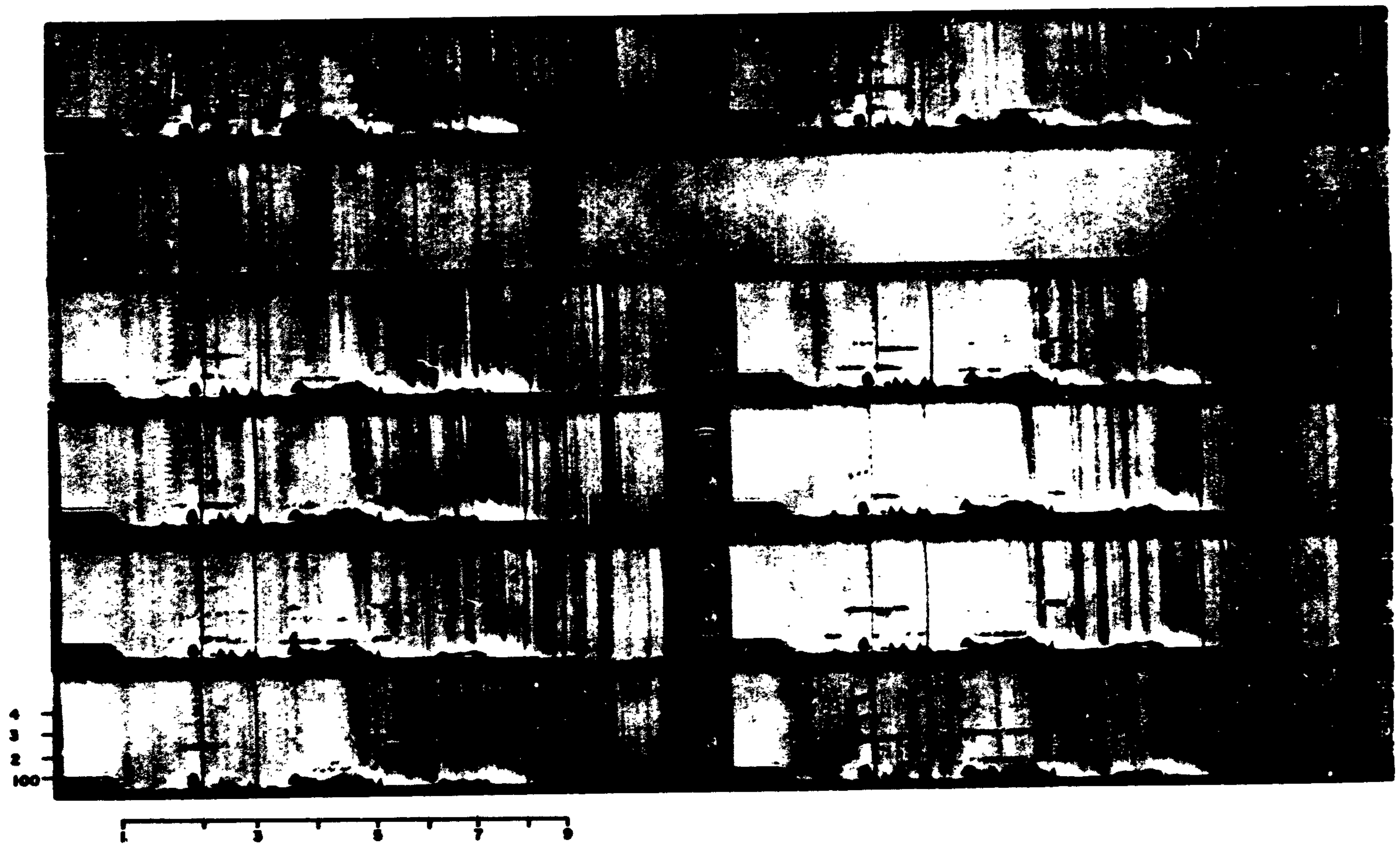
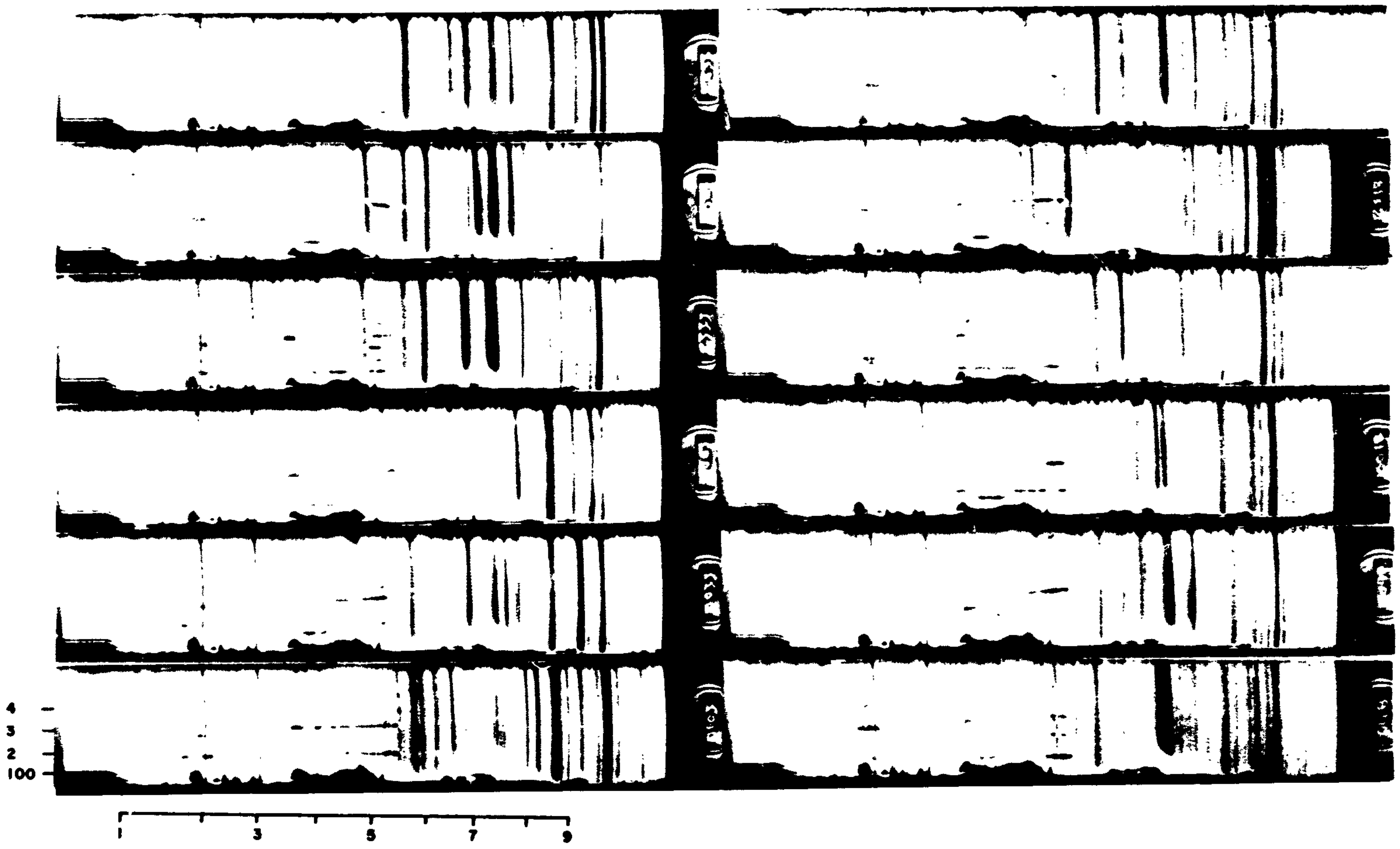
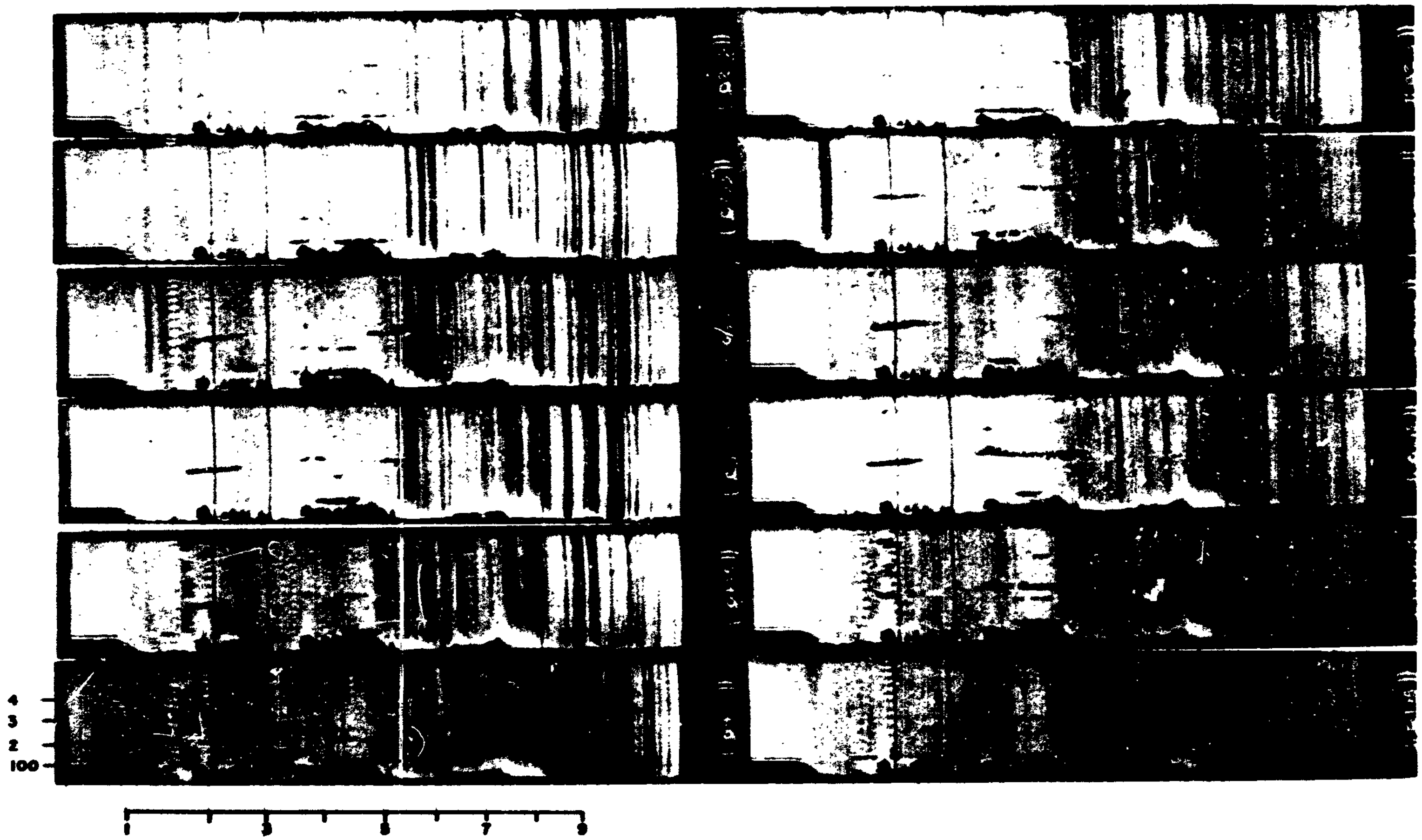


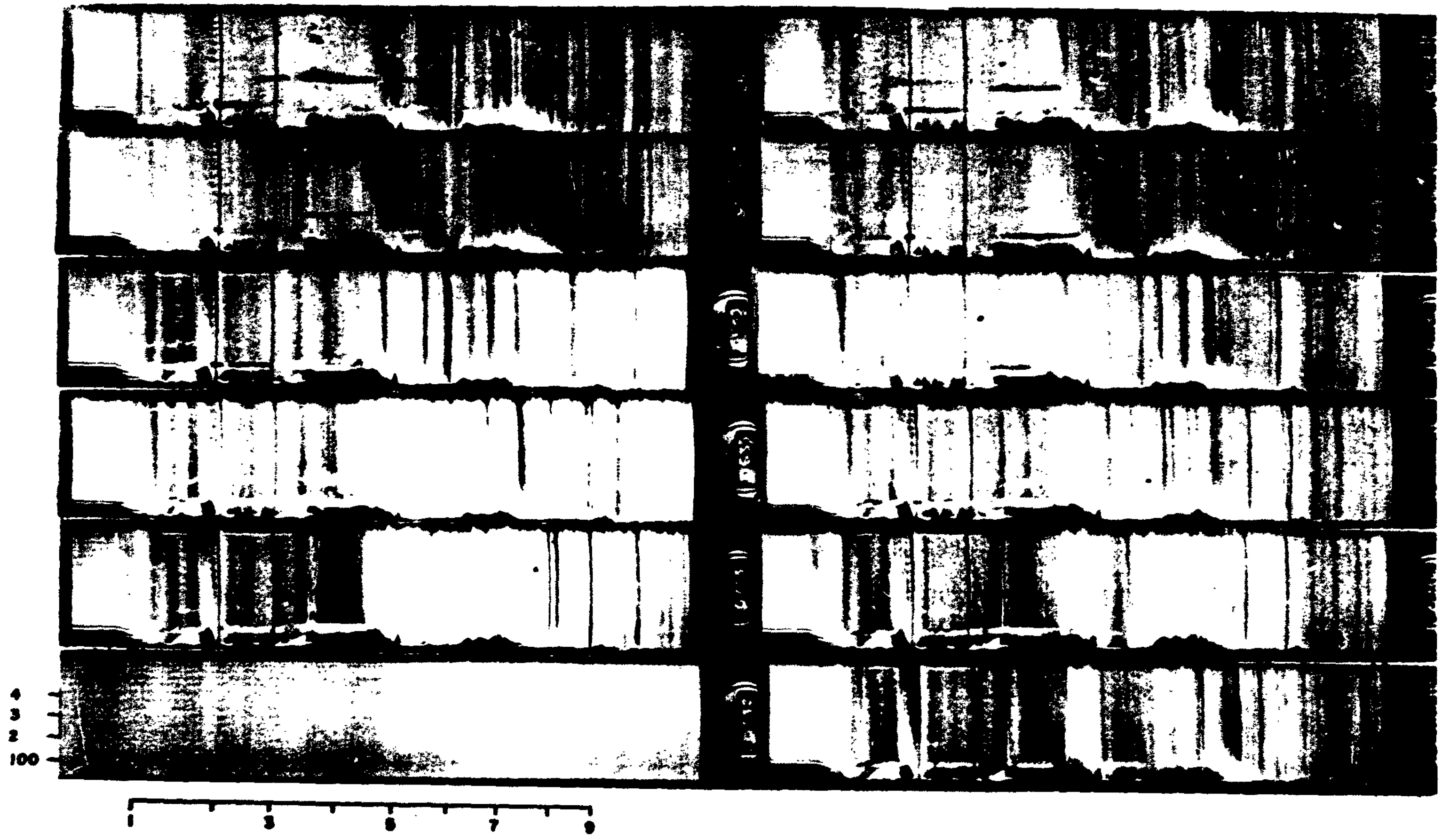
2 APR 2003 - 2218 C= 0.7



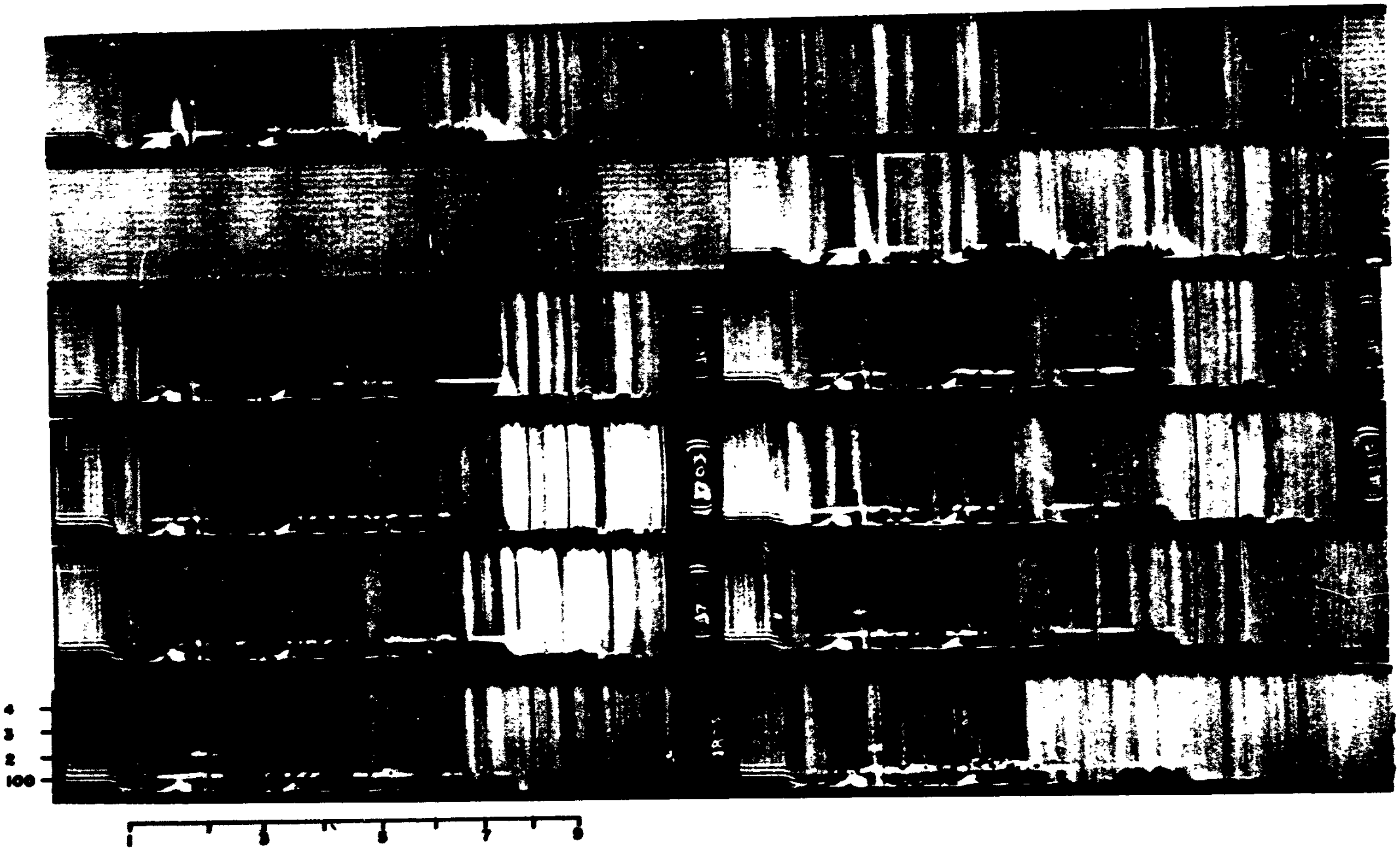
2 APR 2235 - 2348 C=0.7
3 APR 0003 - 0148 C=0.8



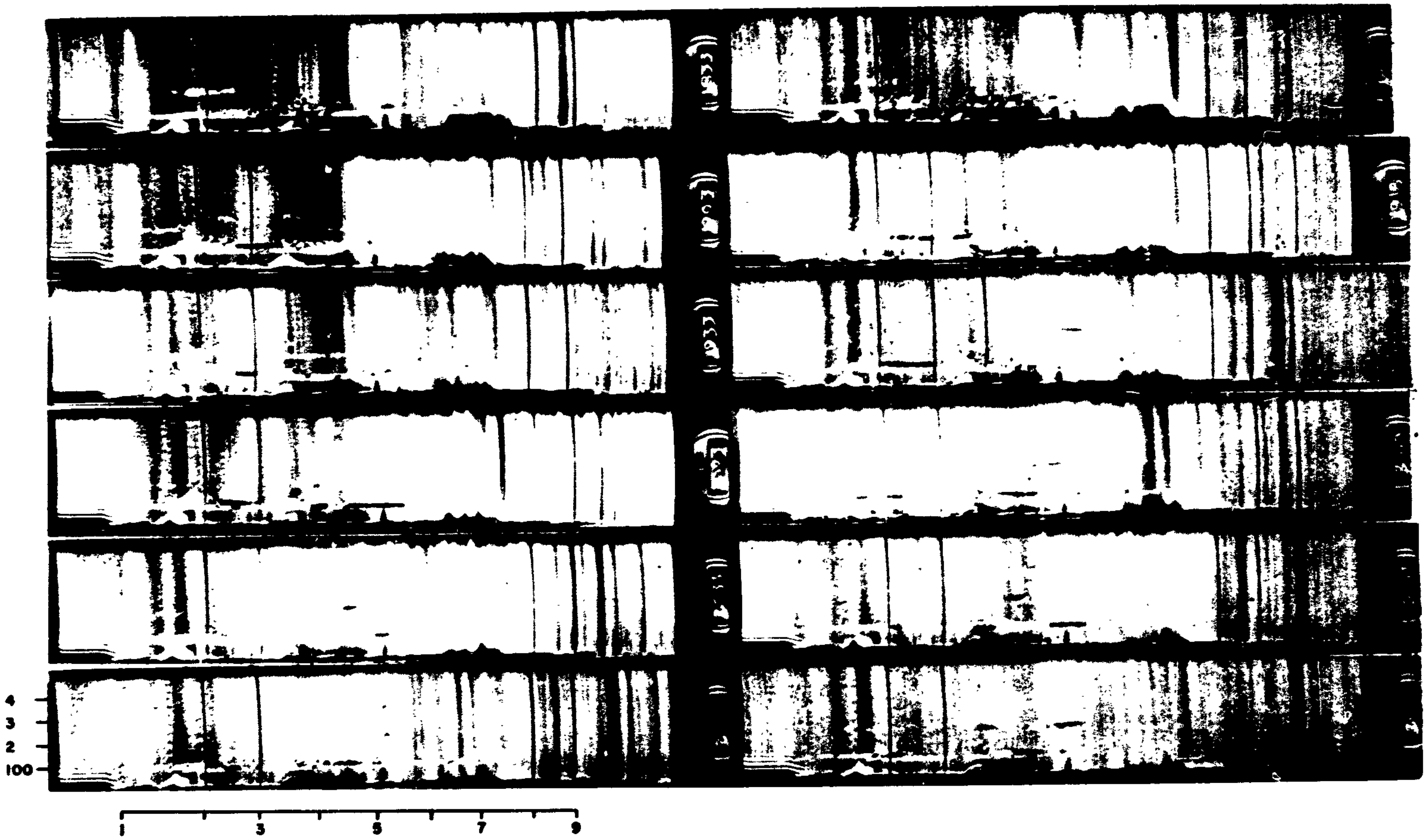
3 APR 0203 - 0448 C=0.8



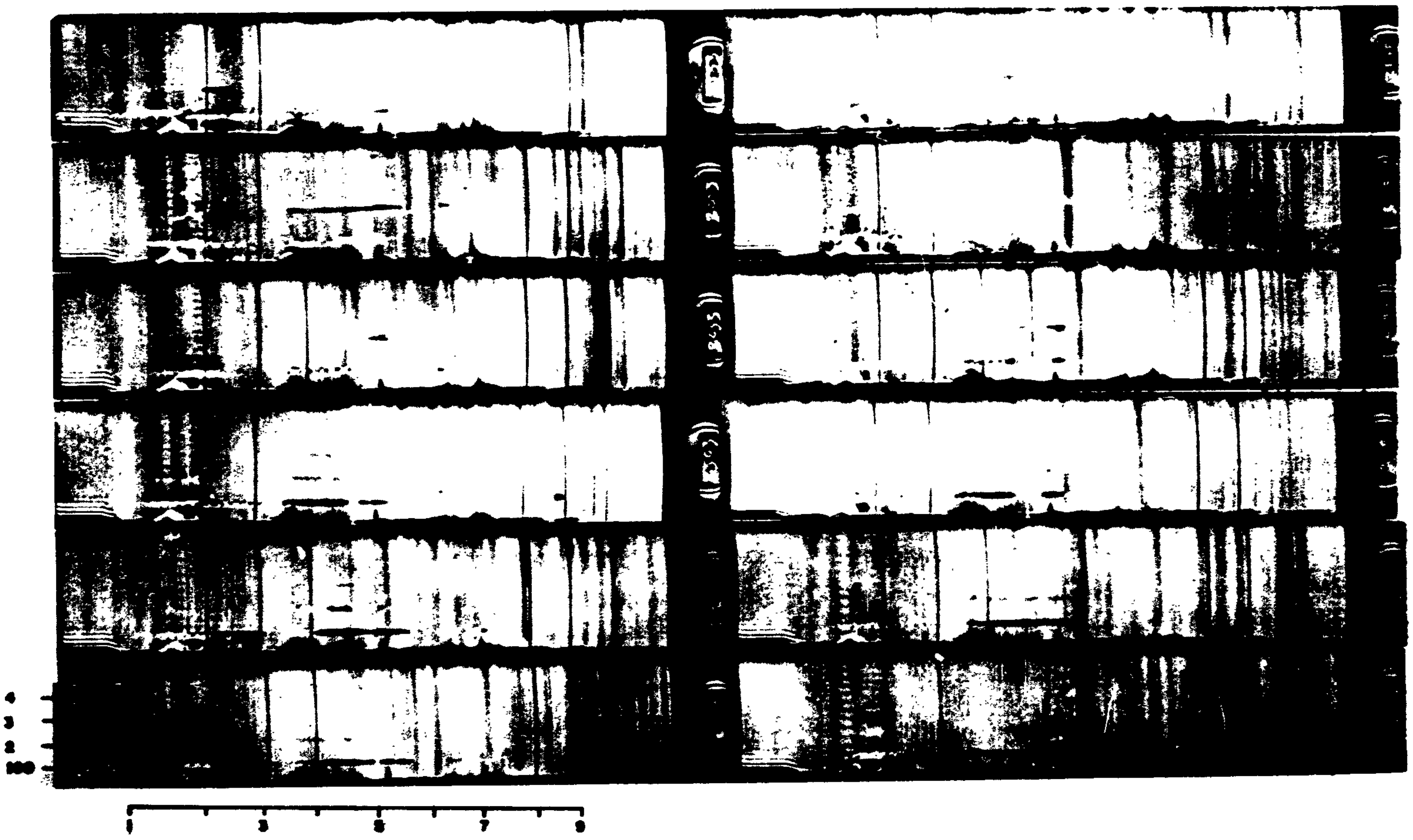
3 APR 0503 - 0748 C = 0.8



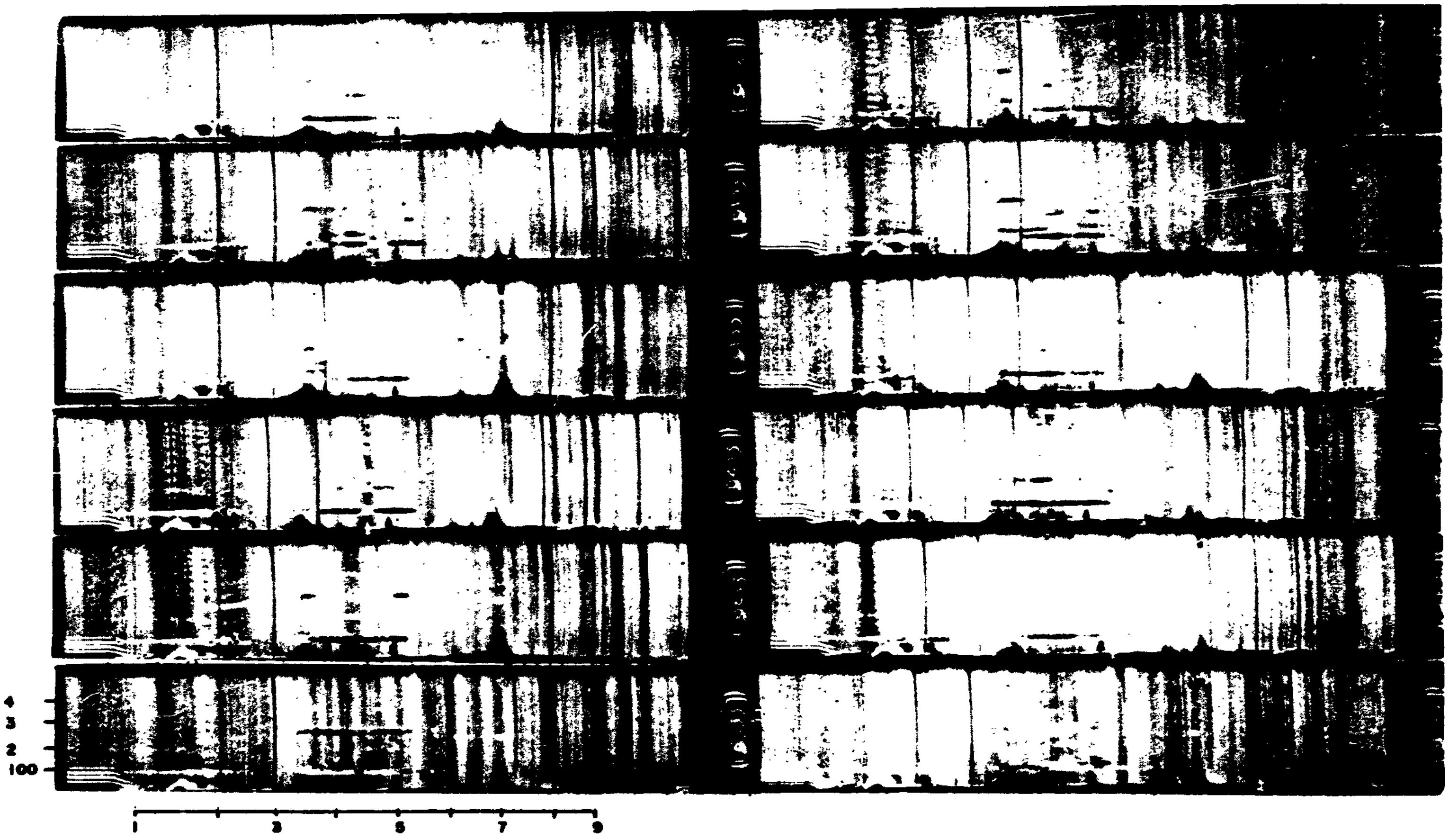
3 APR 1636 – 1818 C = 0.8



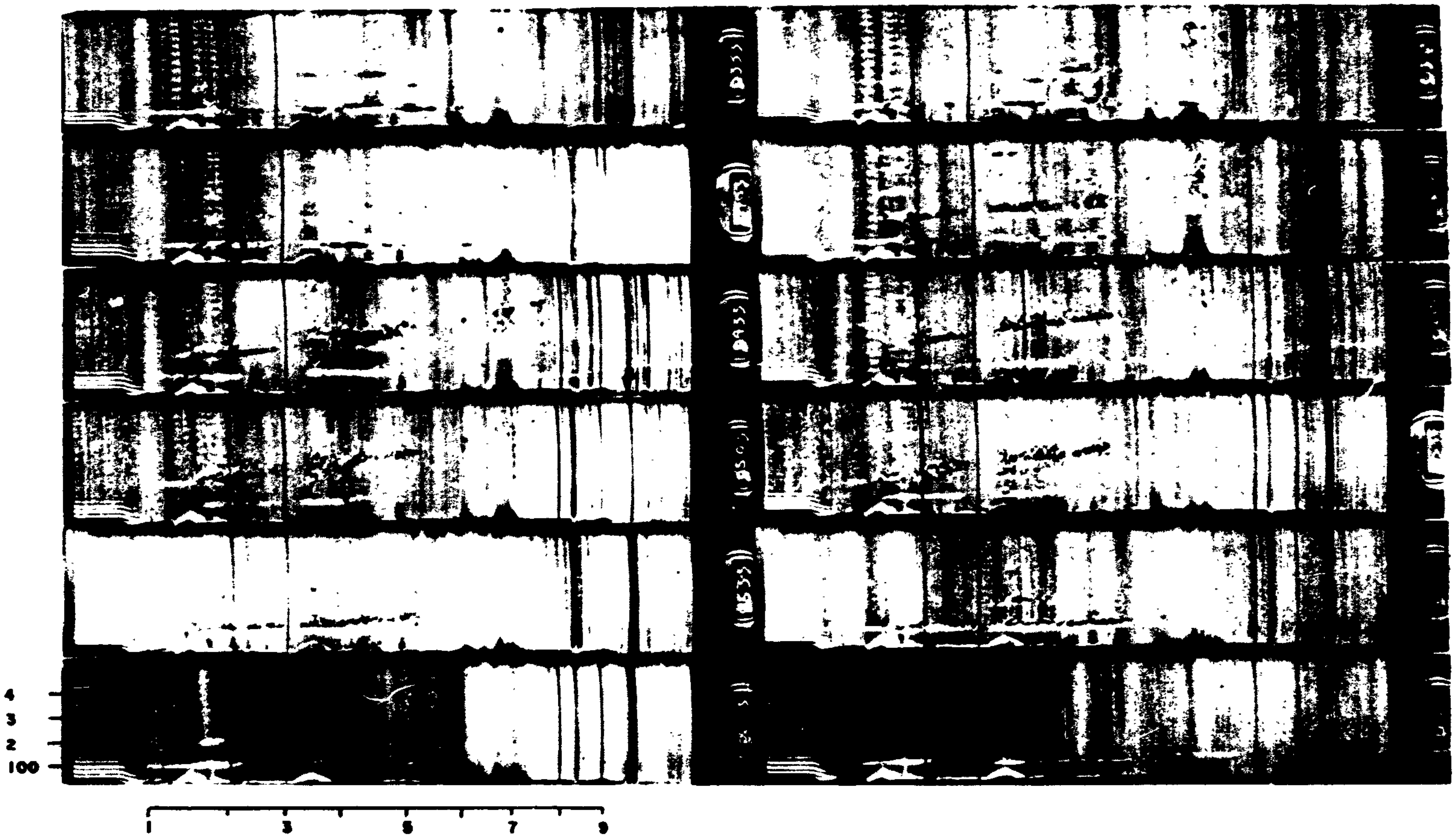
3 APR 1833-2118 C = 0.8



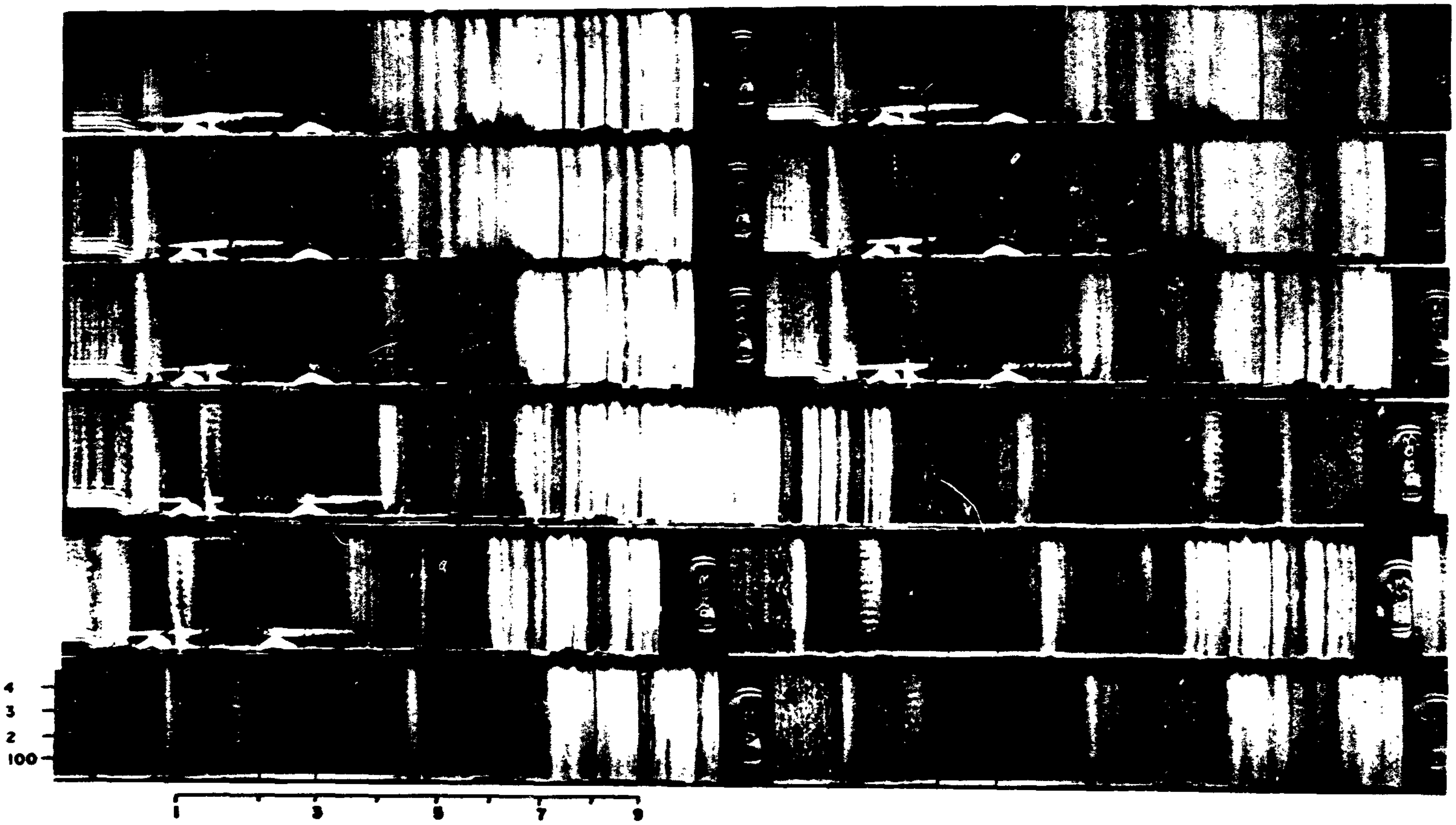
3 APR 2133 - 2418 C = 0.8



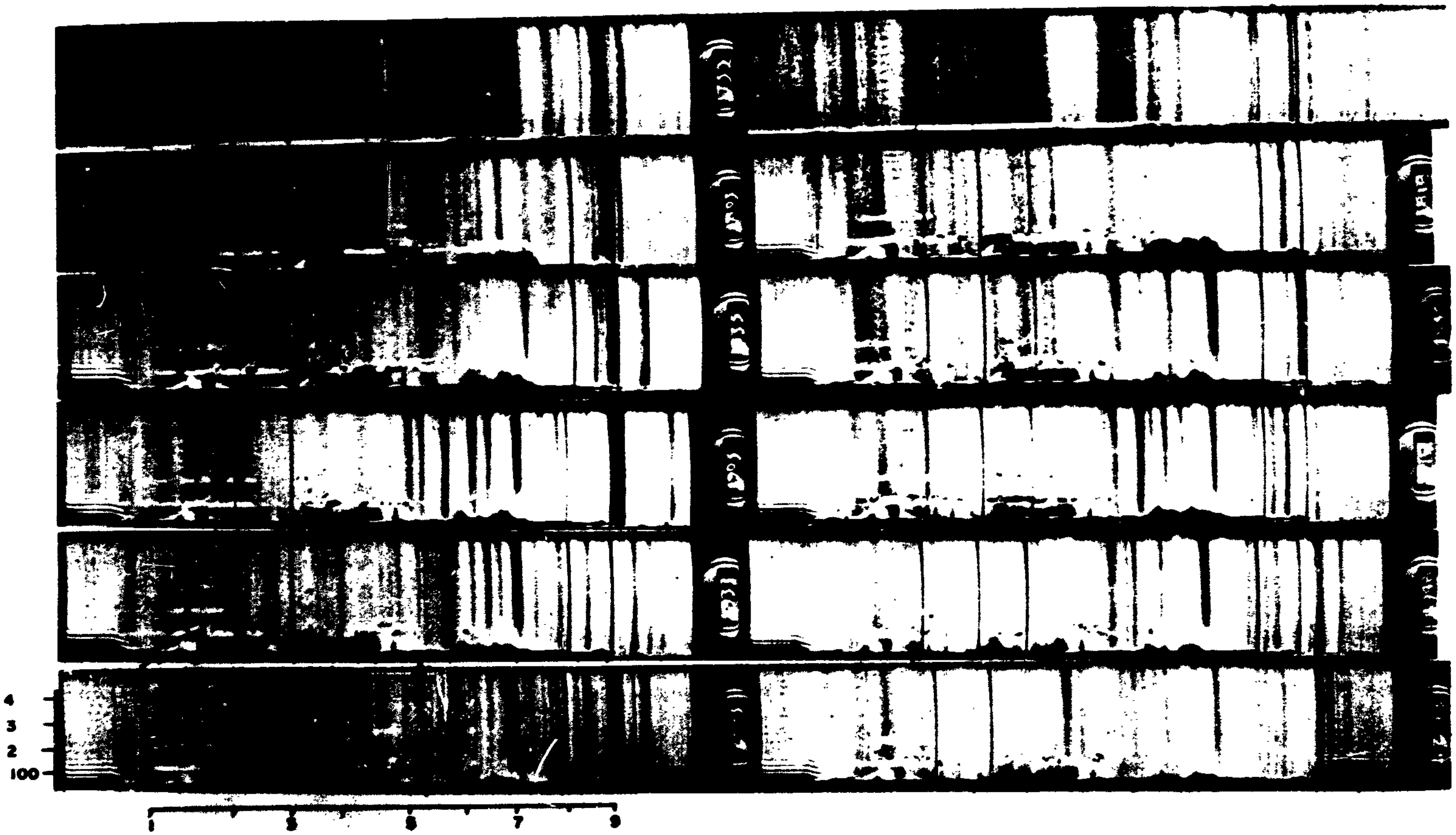
4 APR 0033 - 0318 C = 0.7



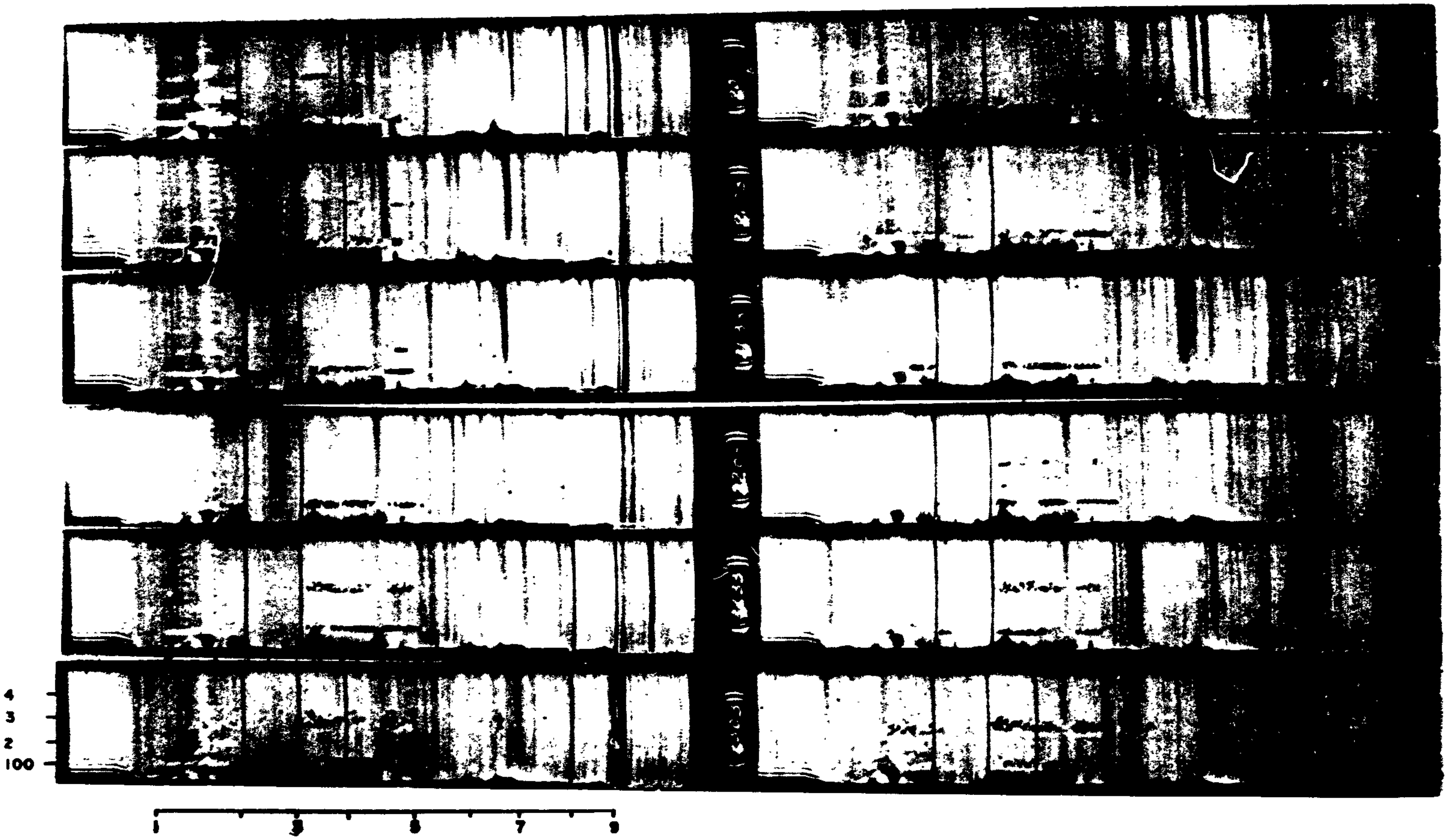
4 APR 0333 - 0618 C = 0.7



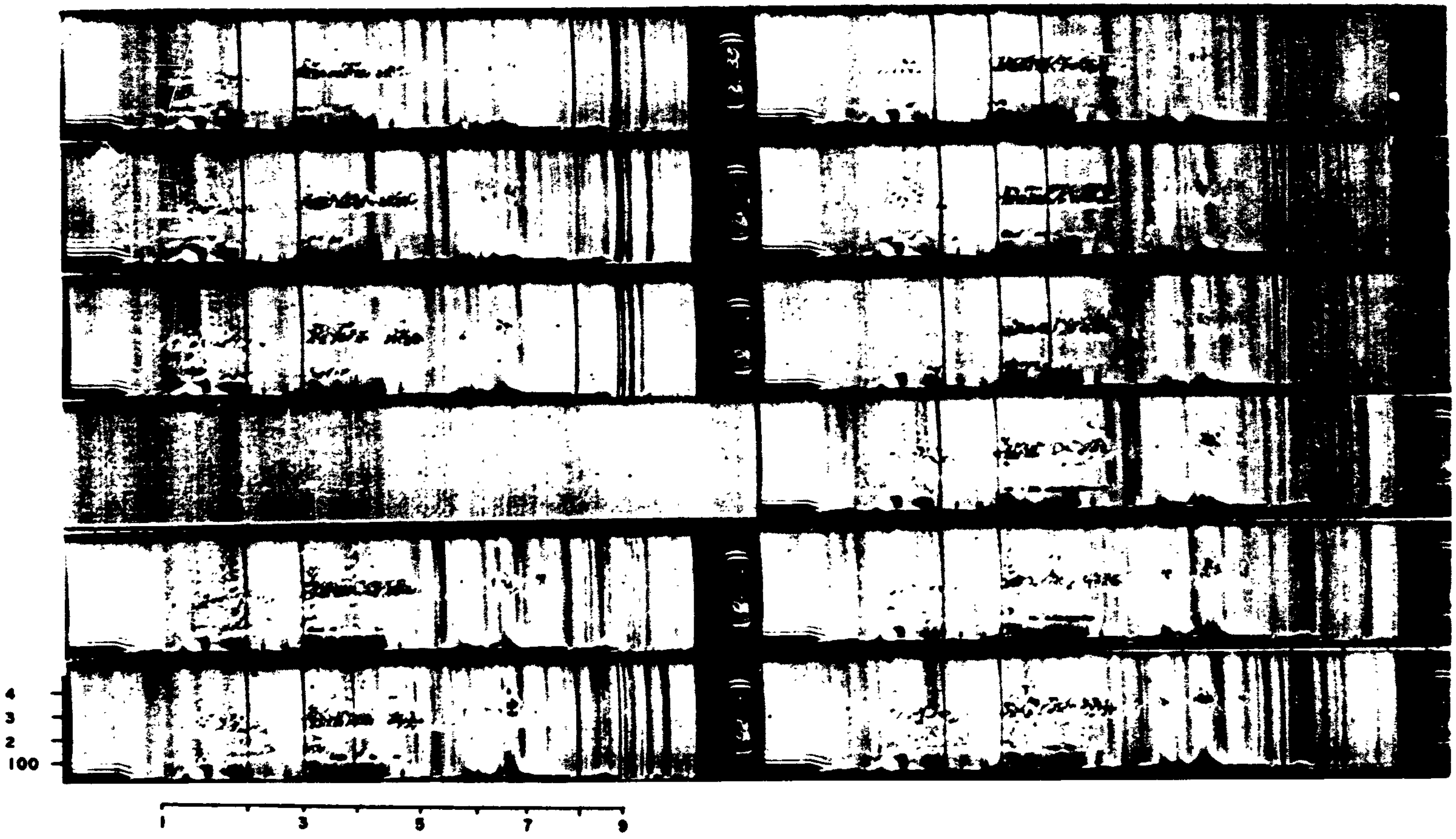
4 APR 0633 - 0833 C= 0.7
4 APR 1703 - 1718 C= 0.7



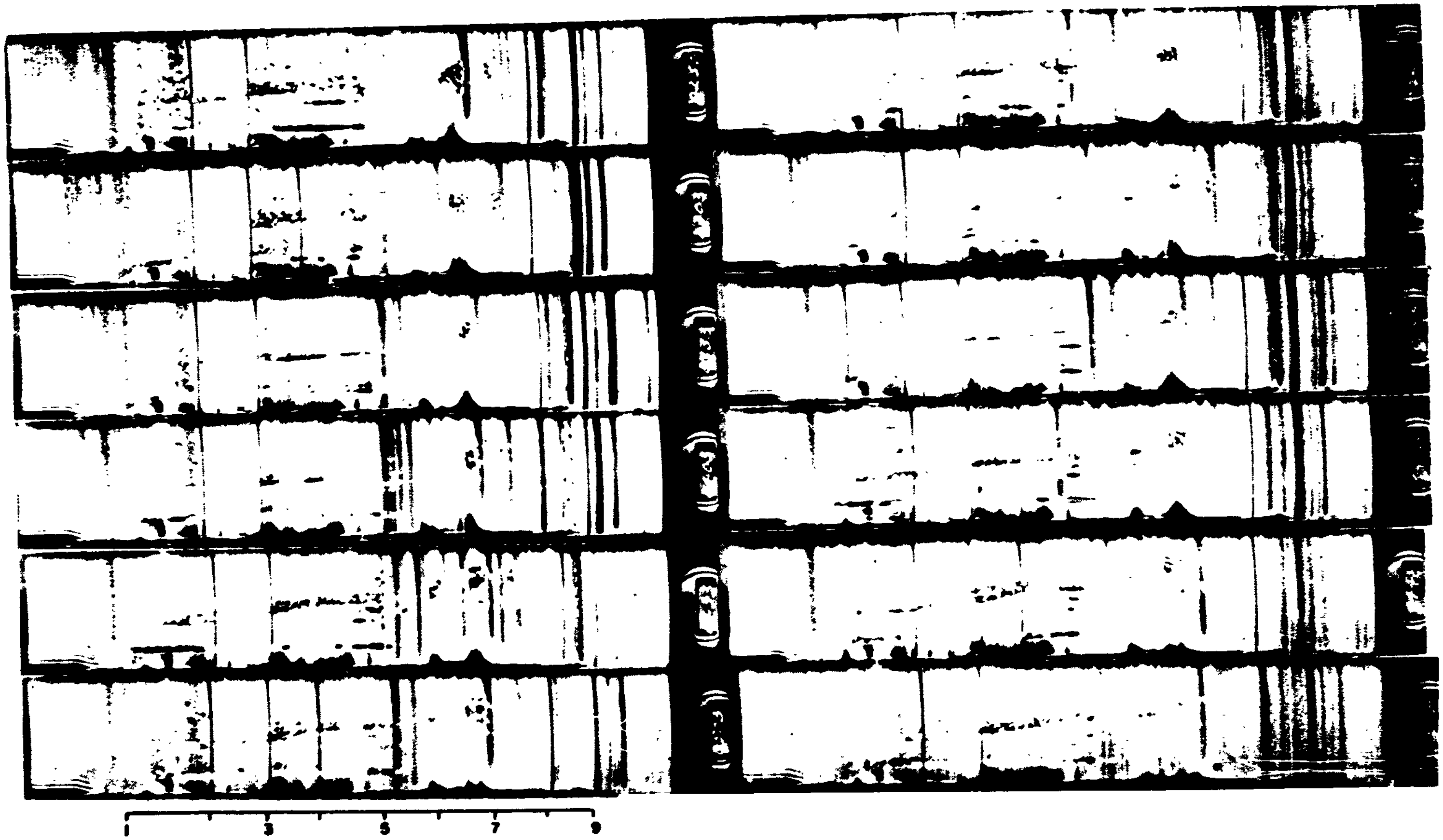
4 APR 1733 - 2018 C= 0.7



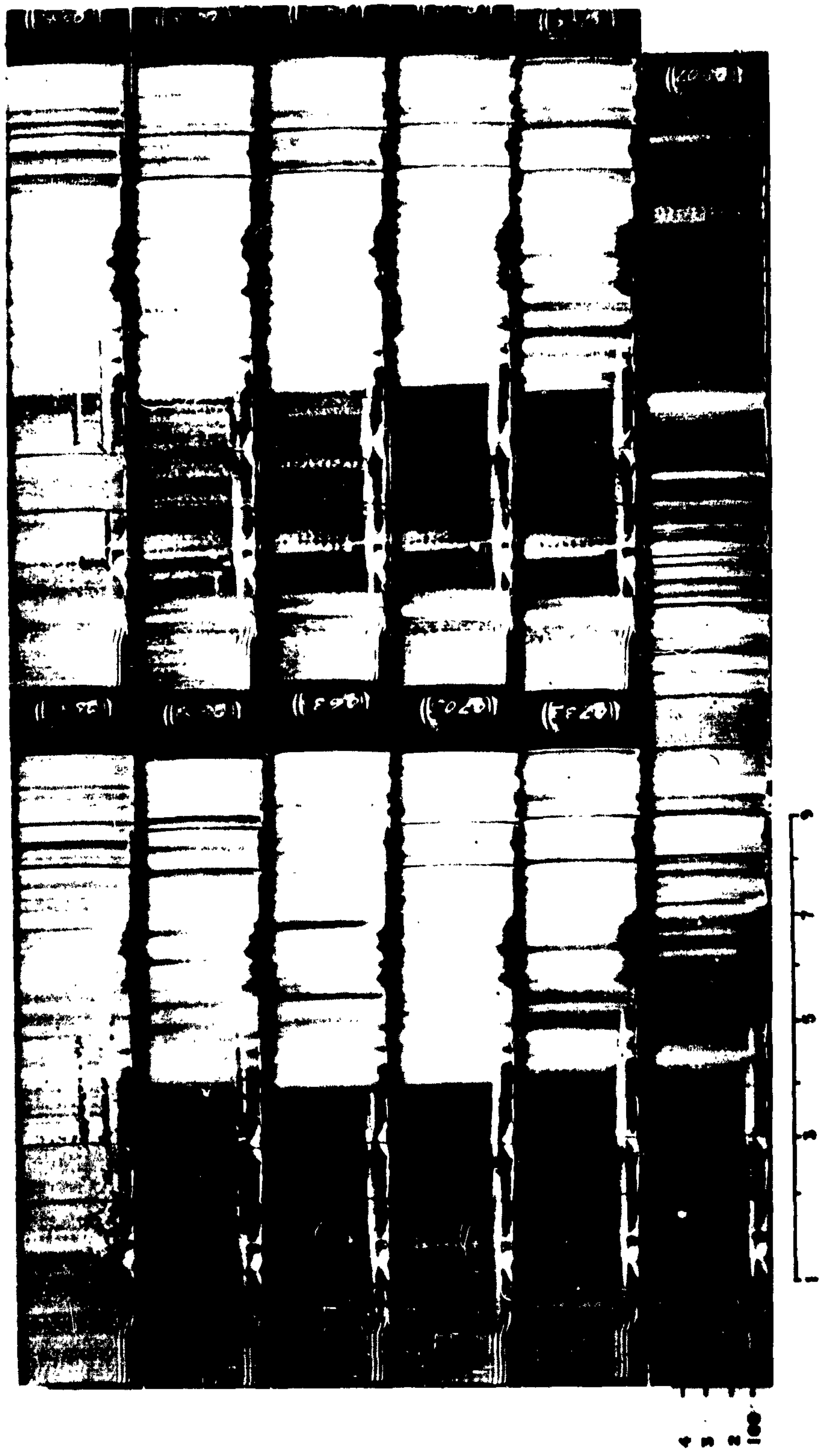
4 APR 2033 - 2318 C= 0.7



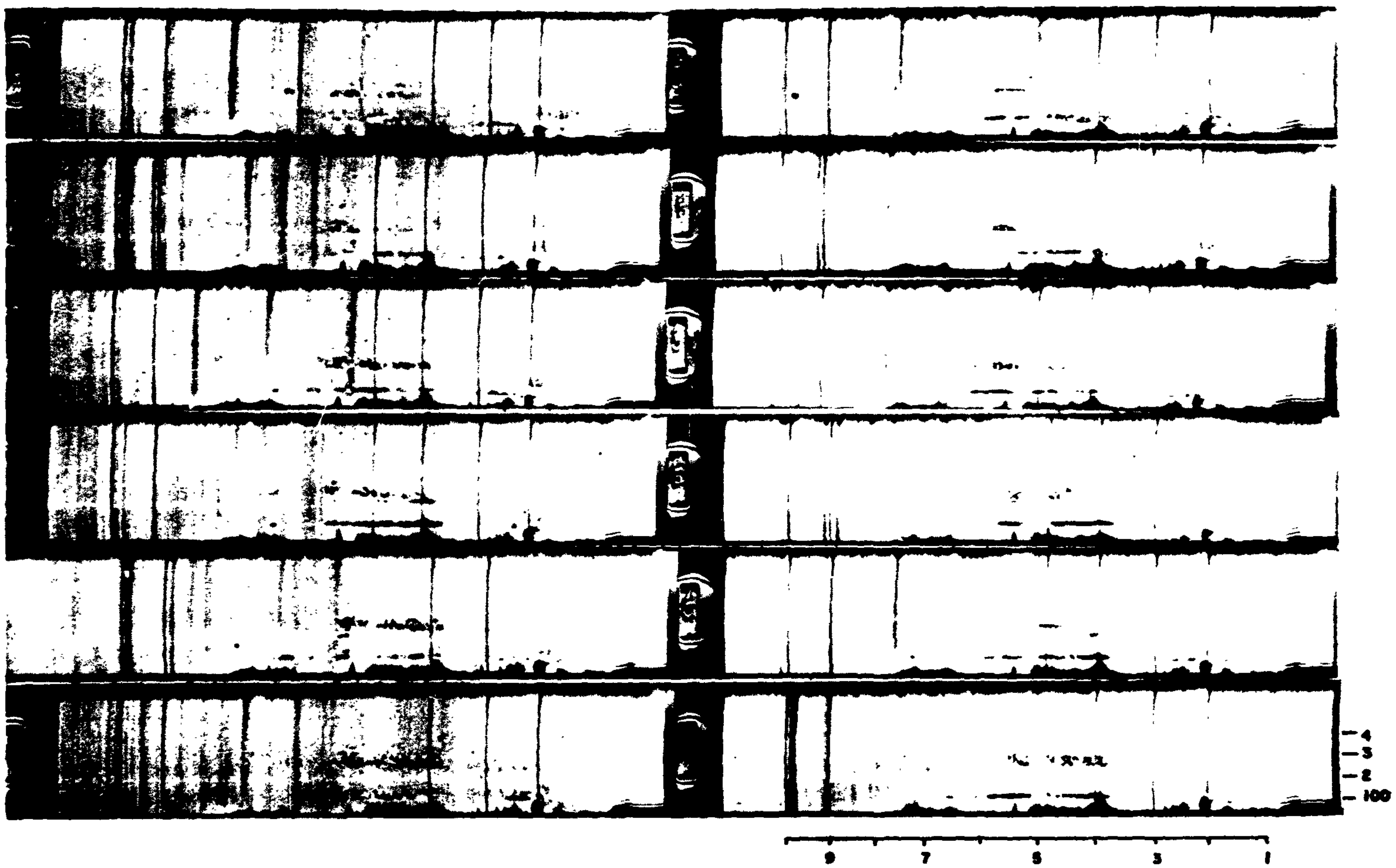
4 APR 2333 - 2348 C = 0.7
5 APR 0003 - 0218 C = 0.4



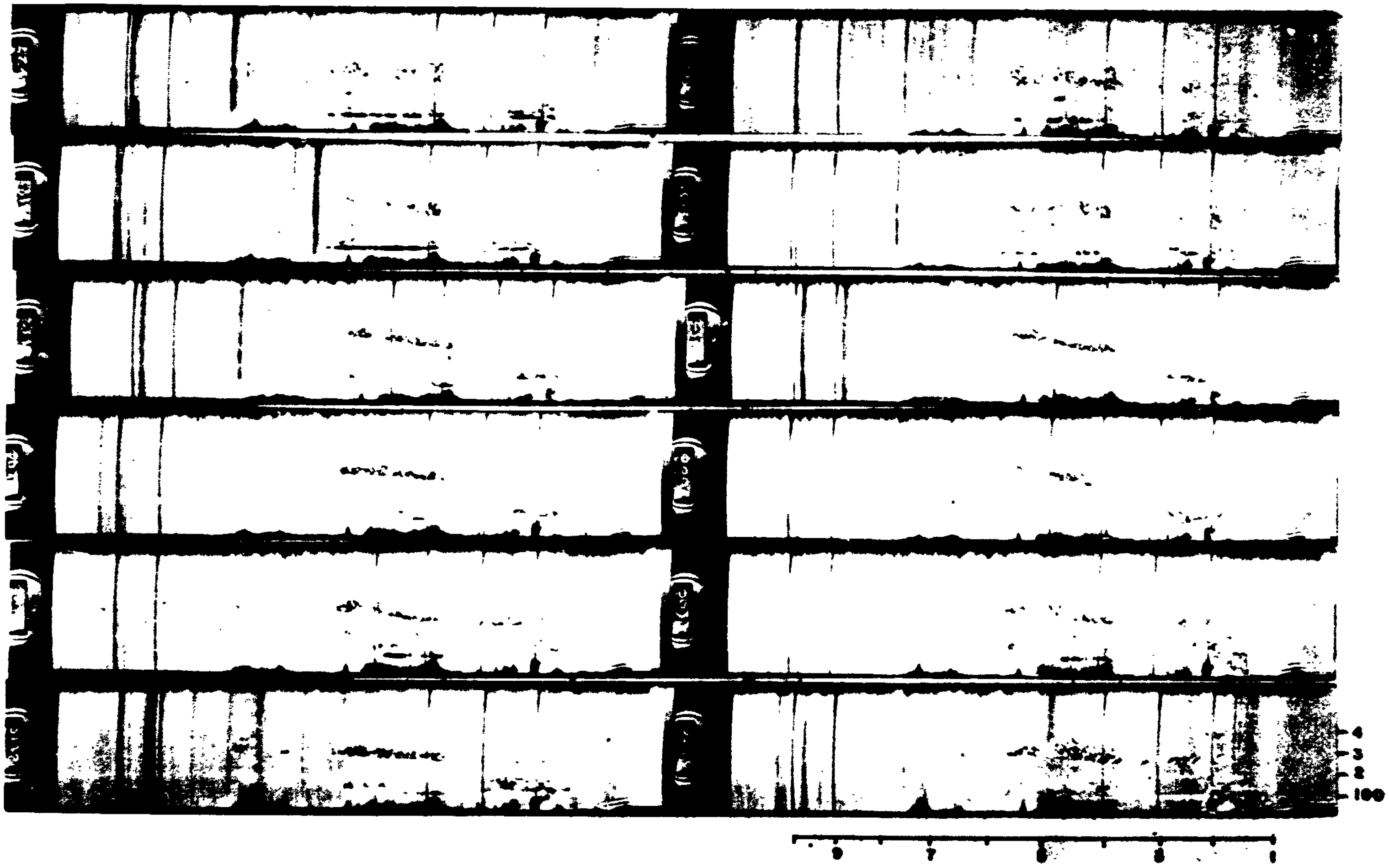
5 APR 0233 - 0518 C = 0.4



5 APR 0535 – 0807 C = 0.4

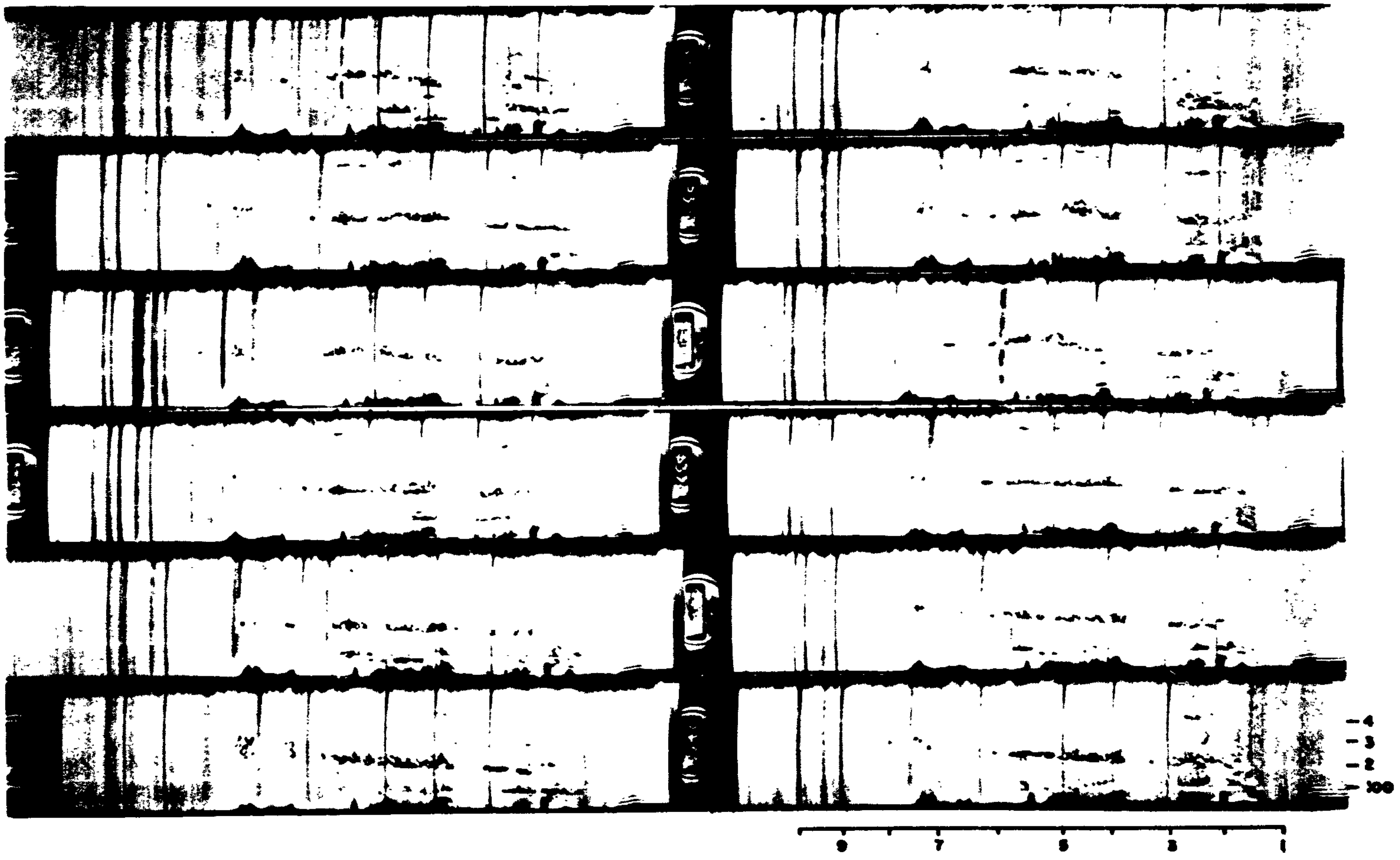


5 APR 1933-2216 C=0.4

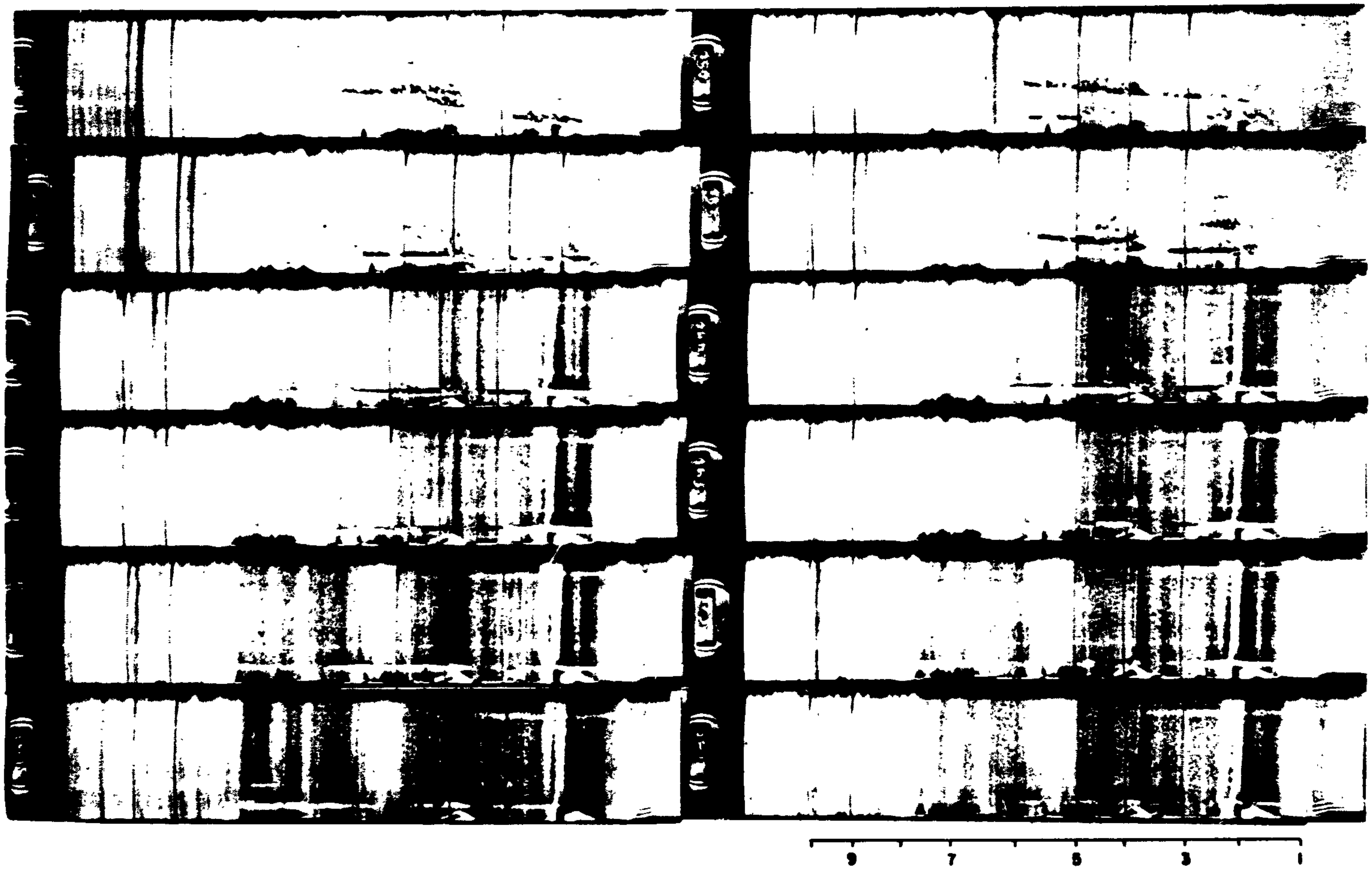


5 APR 2233-2348
6 APR 0003-0148

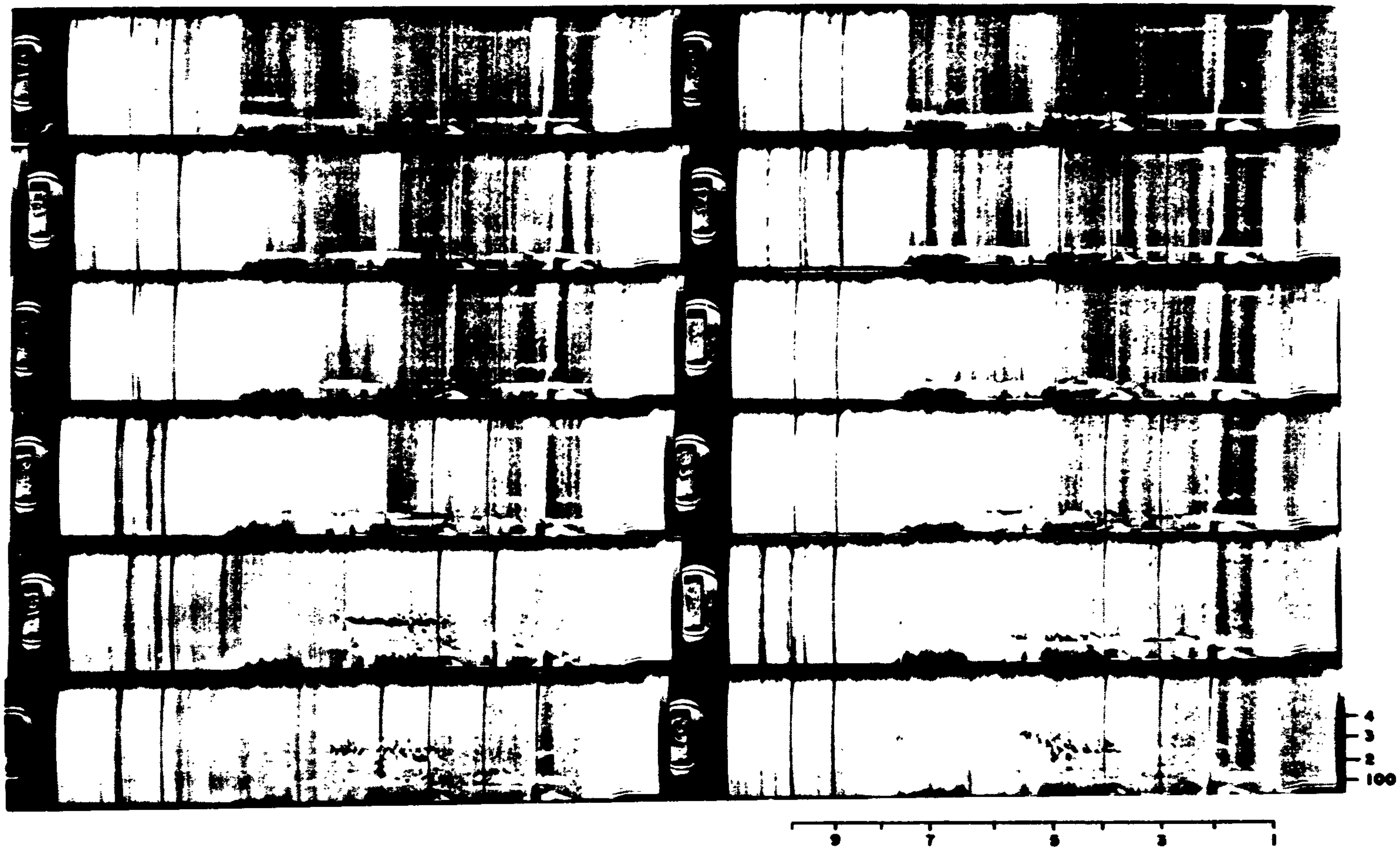
C=04
C=1.3



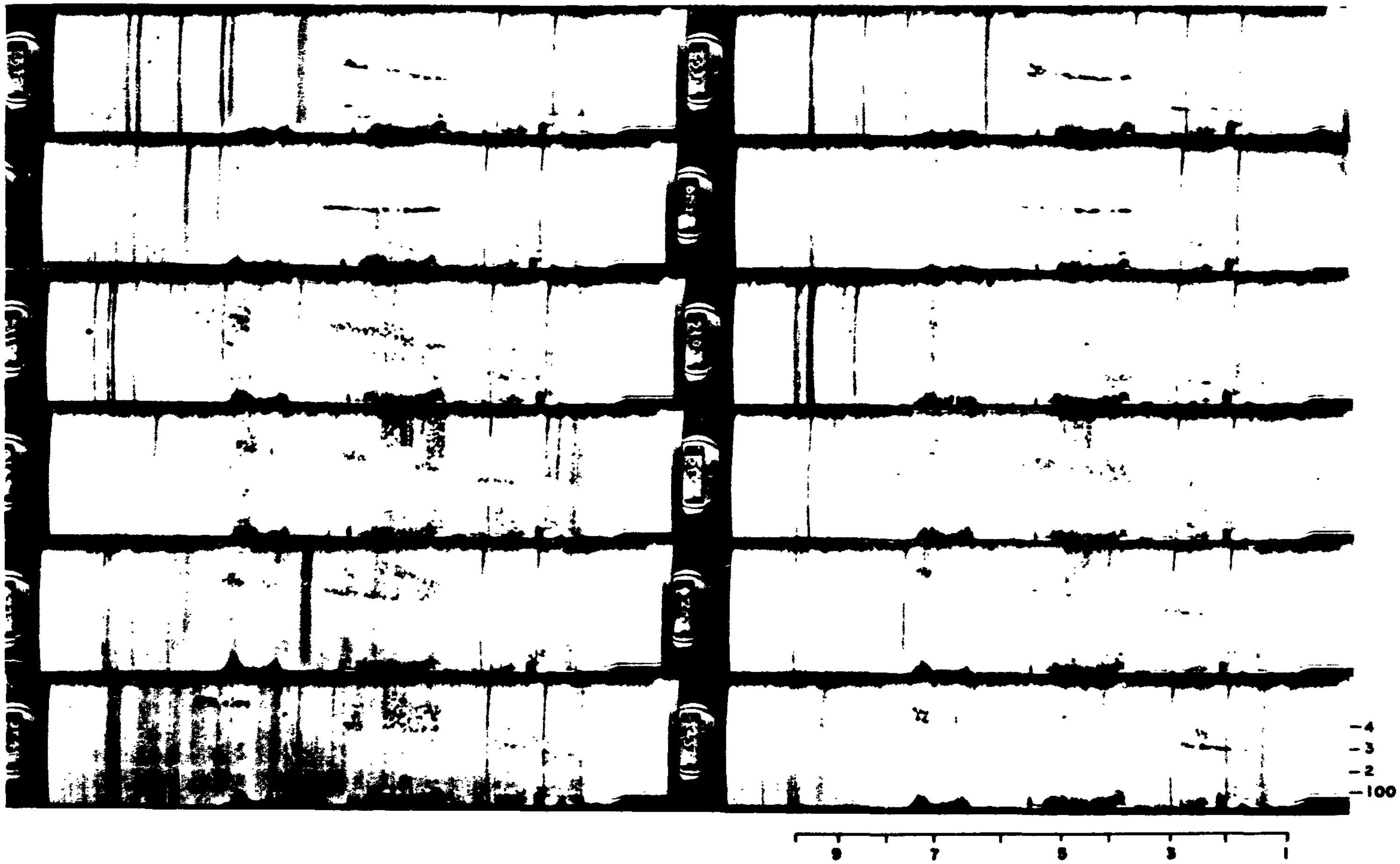
6 APR 0203-0448



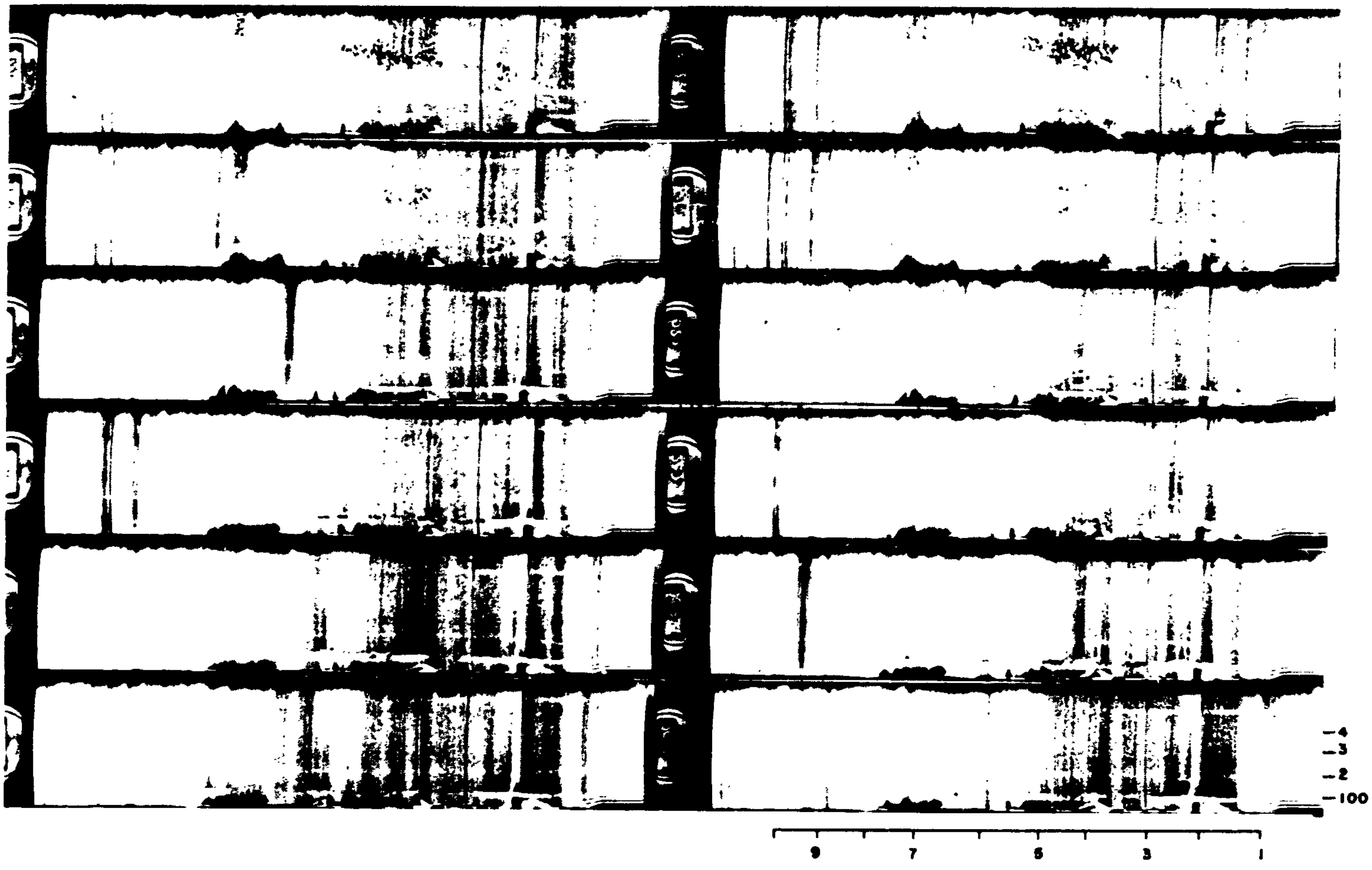
6 APR 0503-0818 C=1.3
6 APR 1641-1645 C=1.3



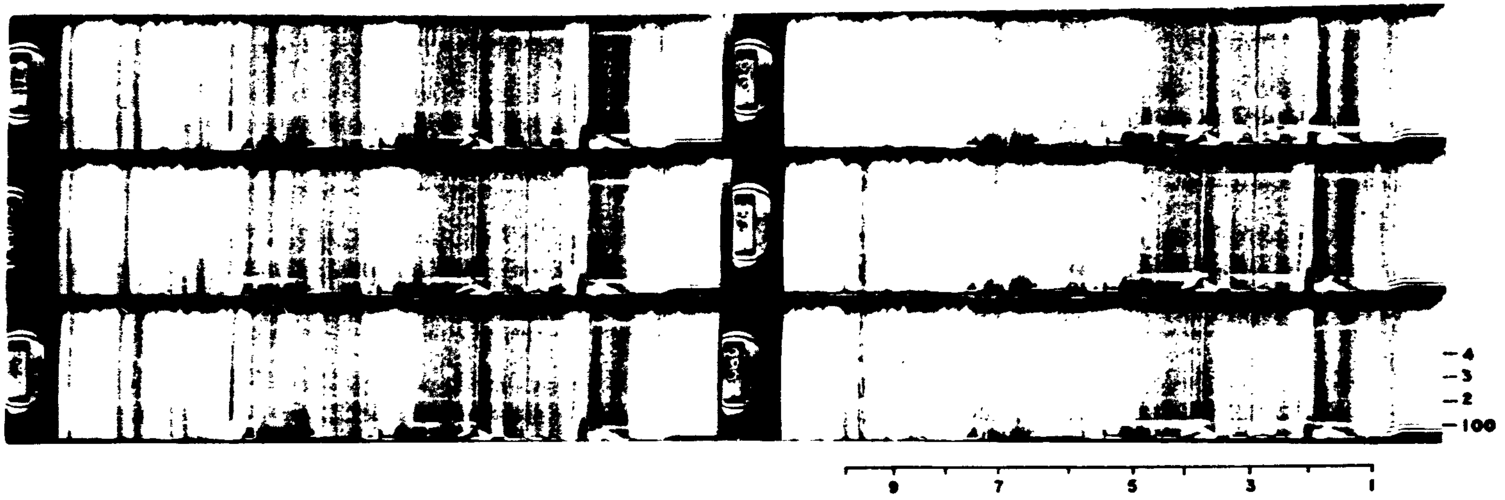
6 APR 1703—1948 C=1.3



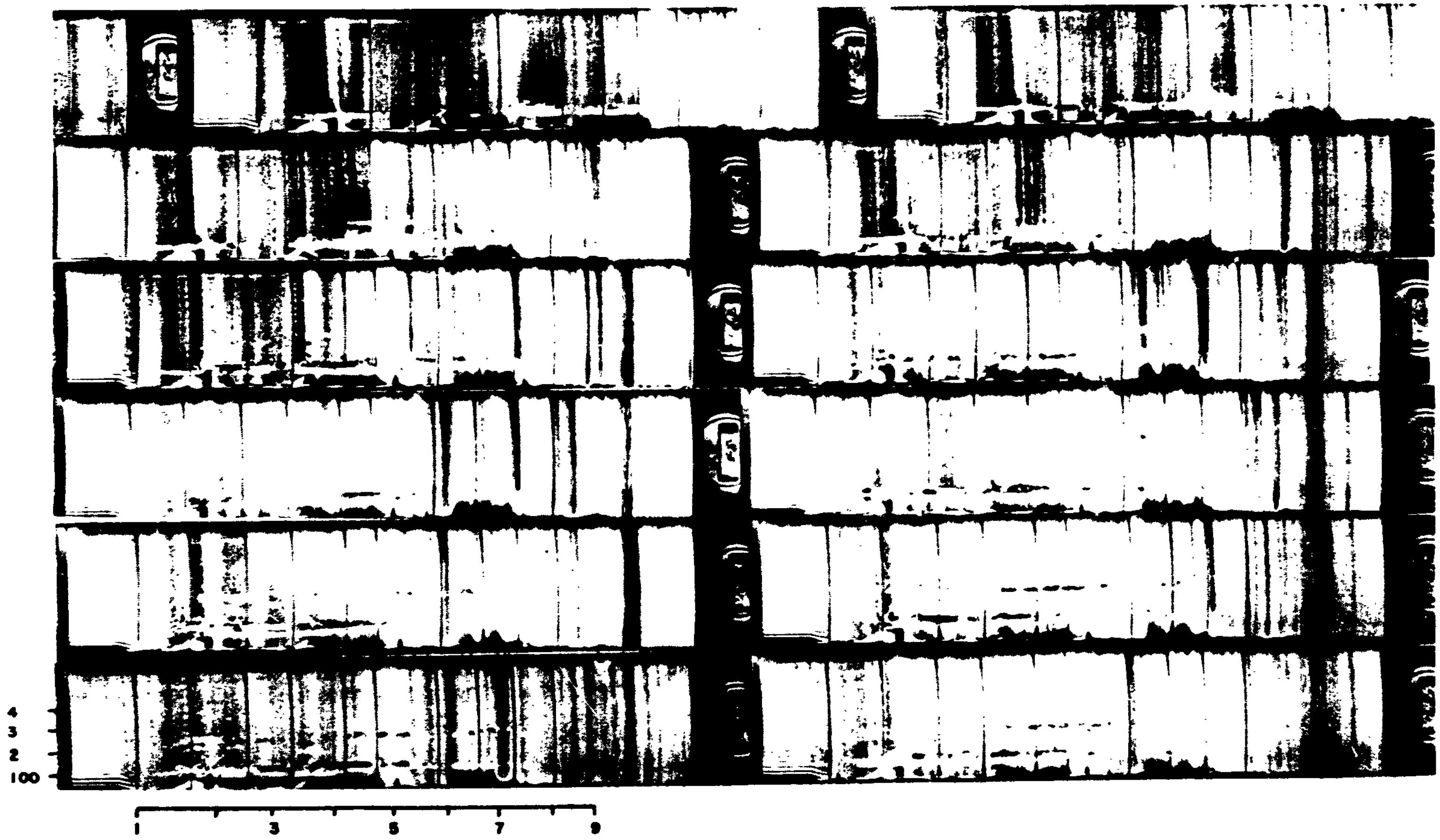
6 APR 2333 – 2348   C = 1.3
7 APR 0018 – 0248   C = 1.6



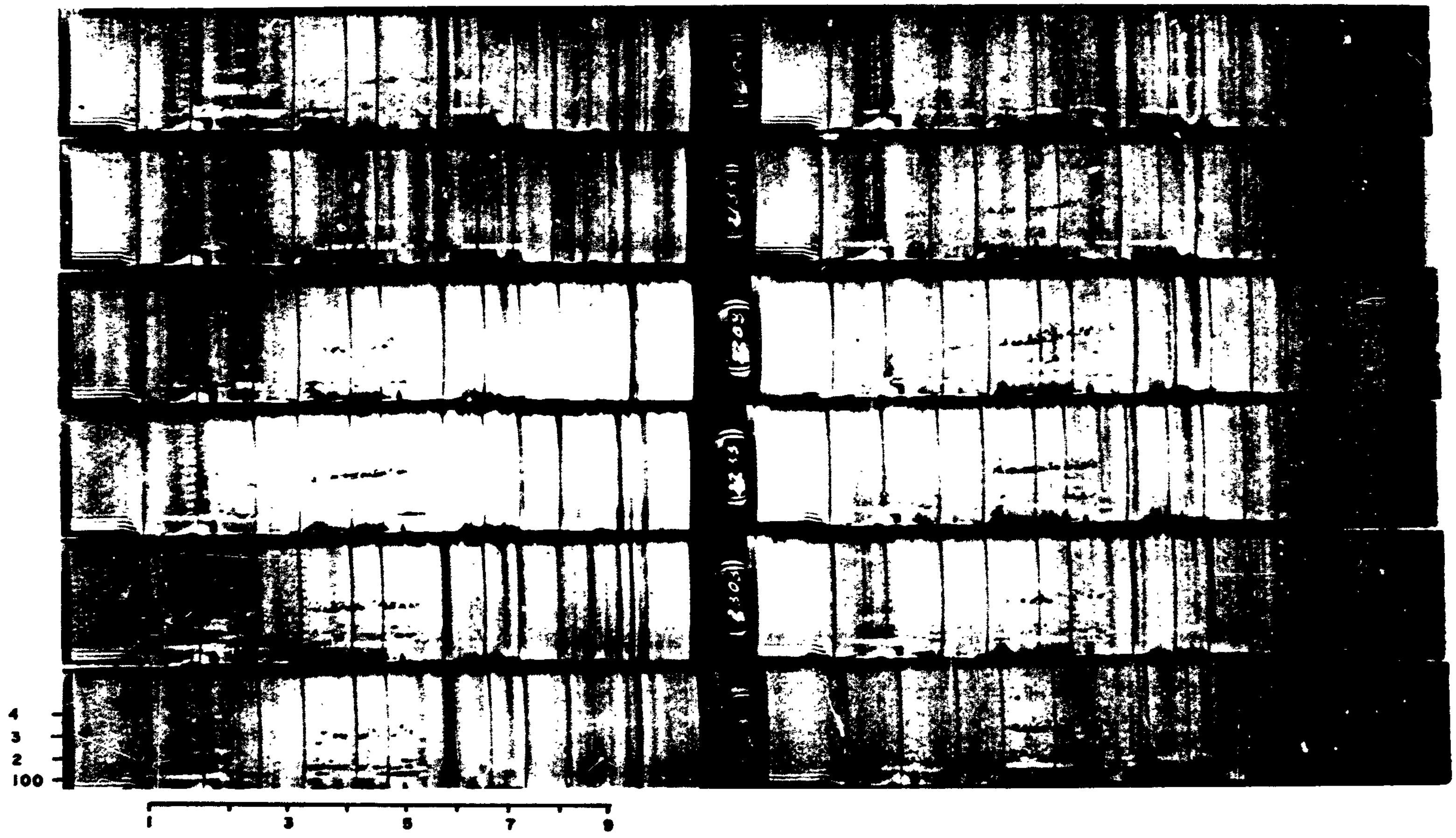
7APR 0333-0648 C=1.6



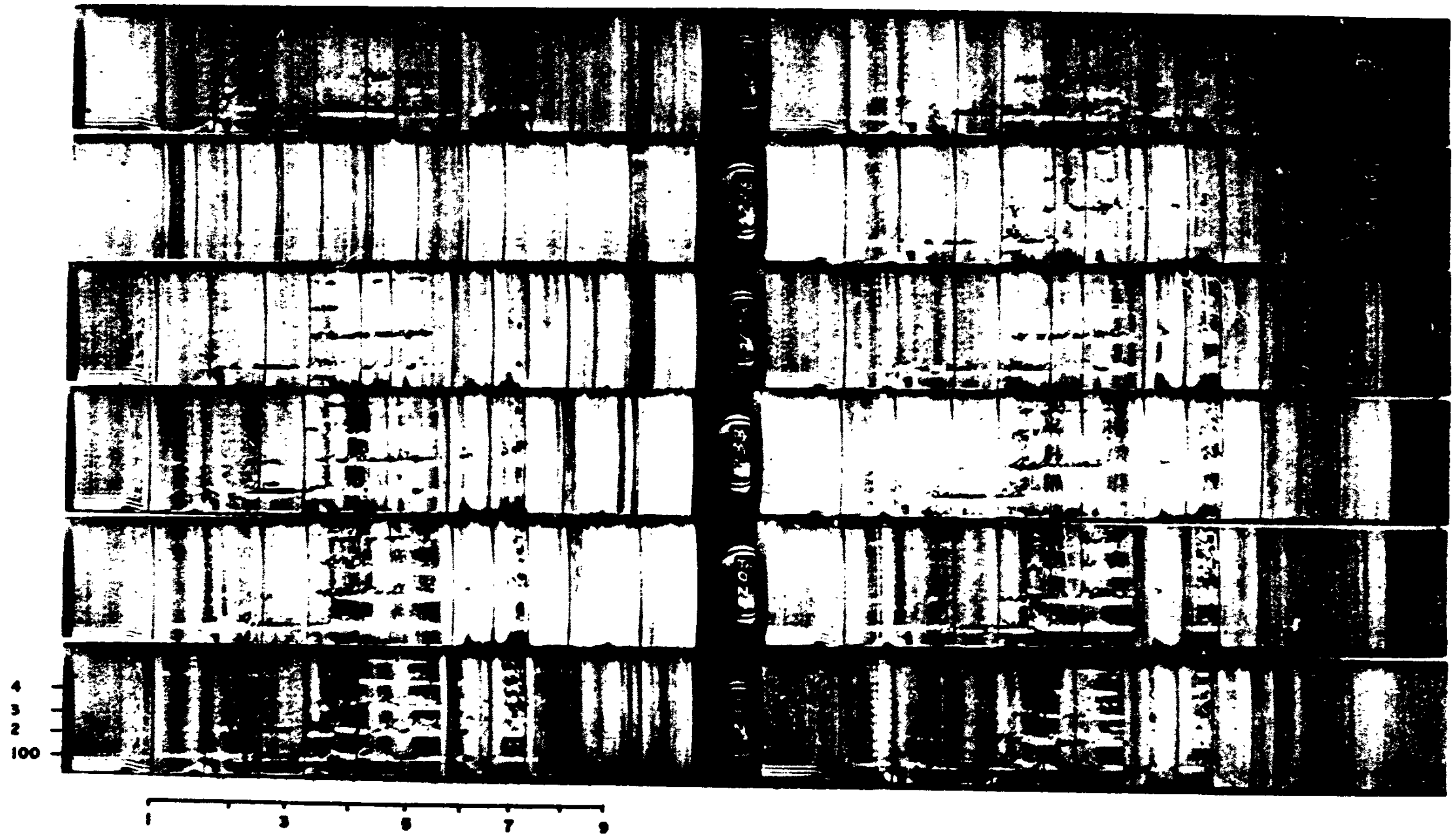
7 APR 0703-0833 C=1.6



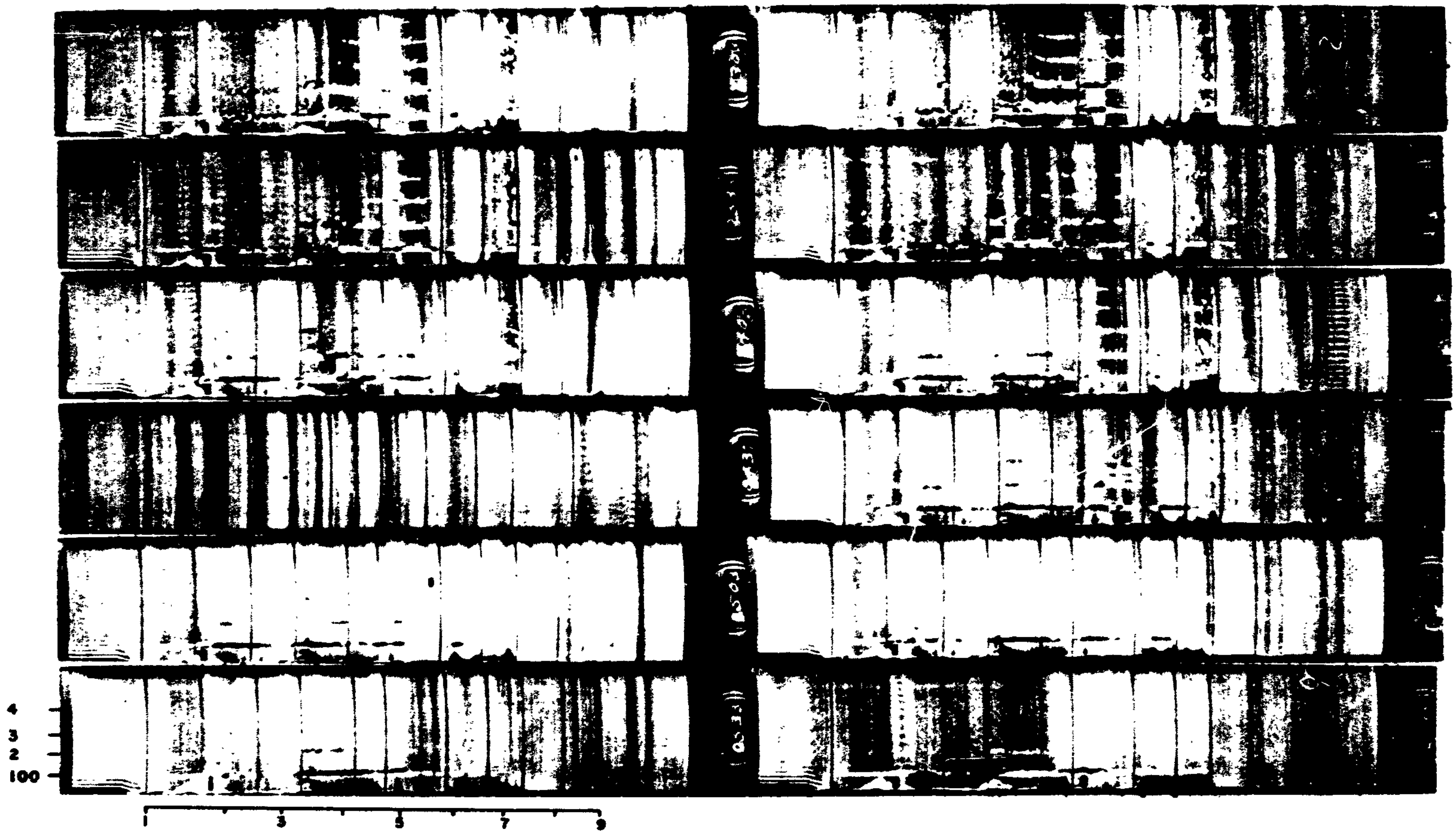
8 APR 1622-2048 C=1.4



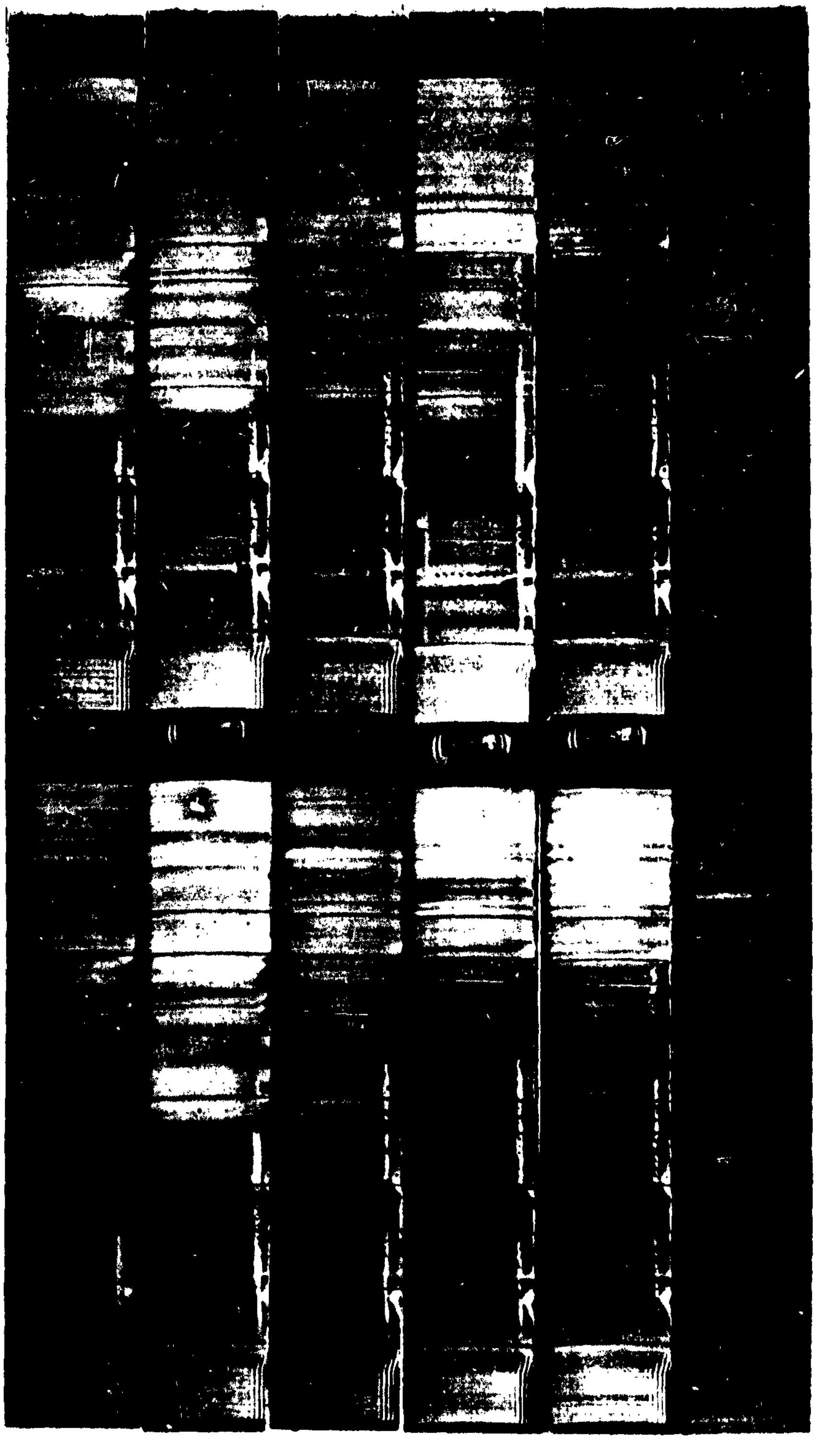
8 APR 2103 - 2348 C = 1.4



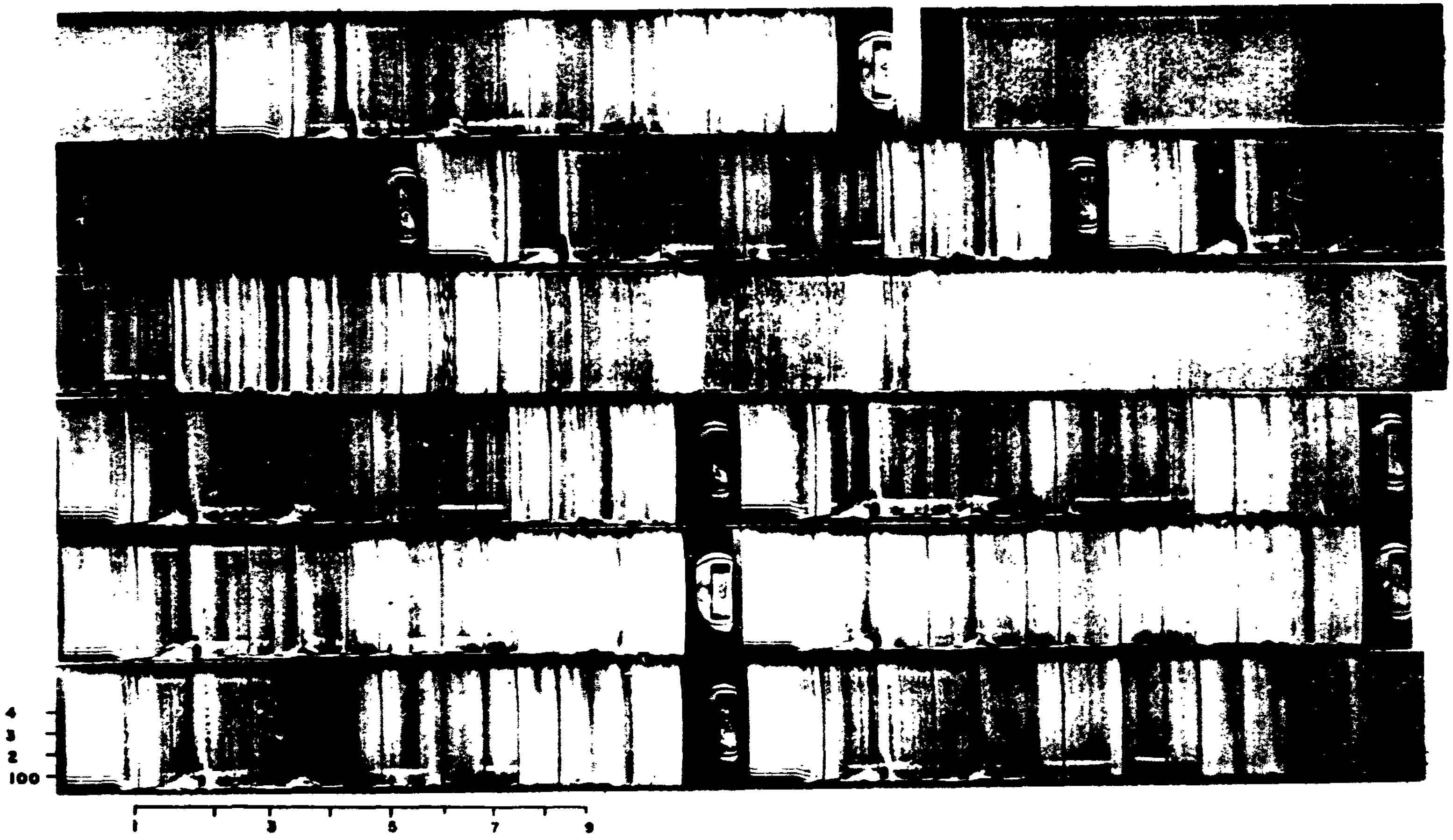
9 APR 0003-0248 C = 0.6



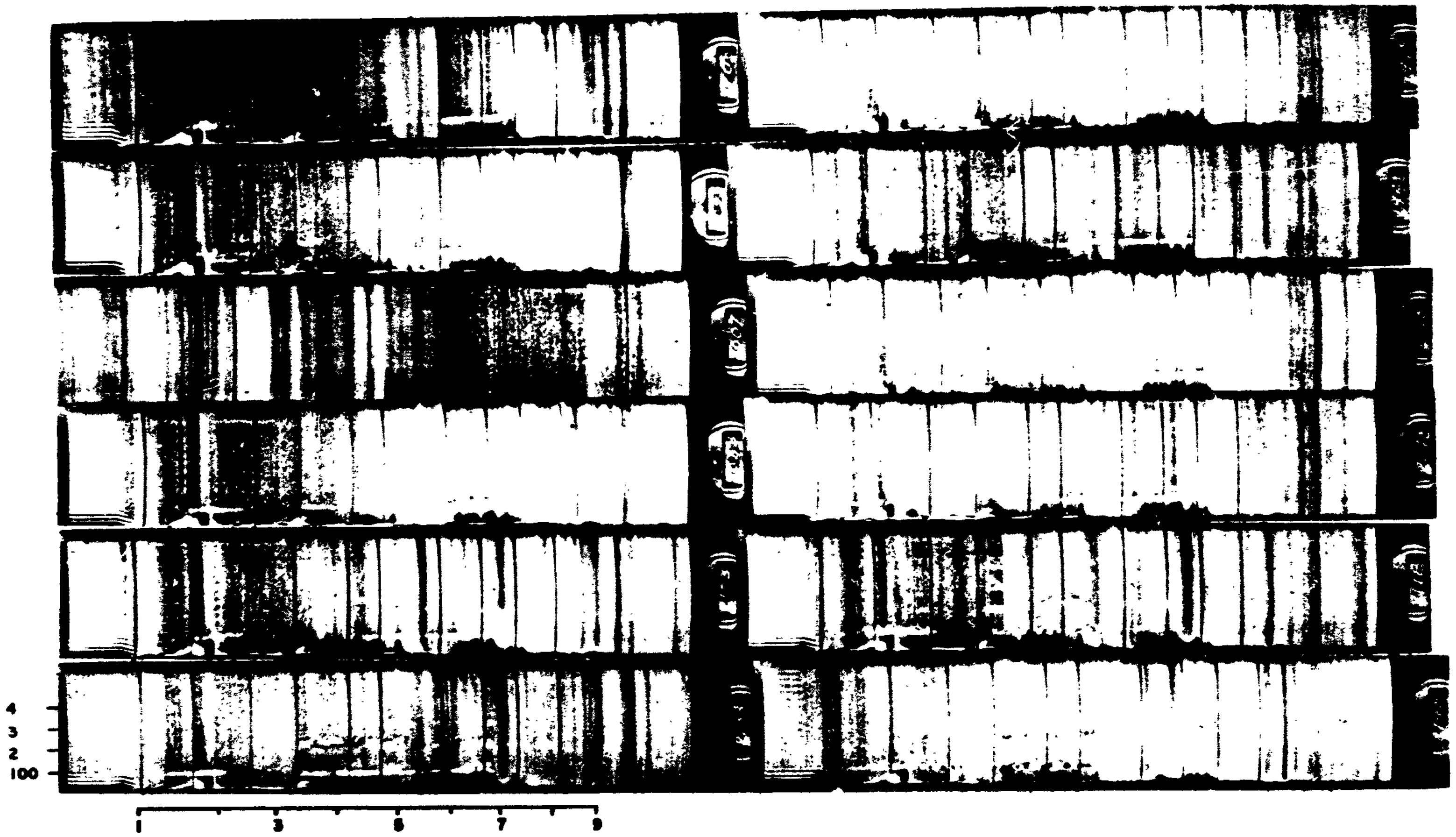
9 APR 0303 - 0548 C=0.8



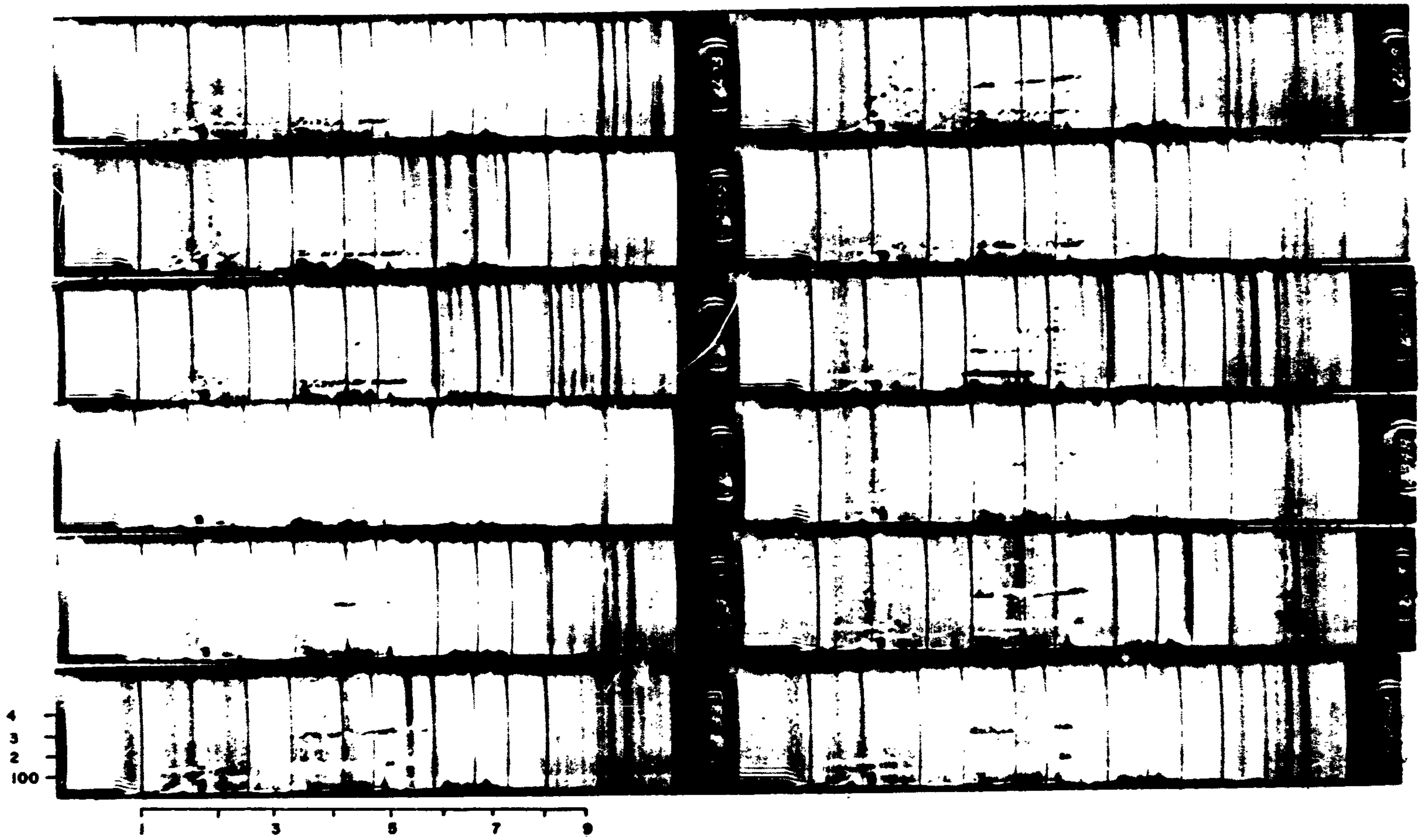
9 APR 0603 - 0818 C = 0.8



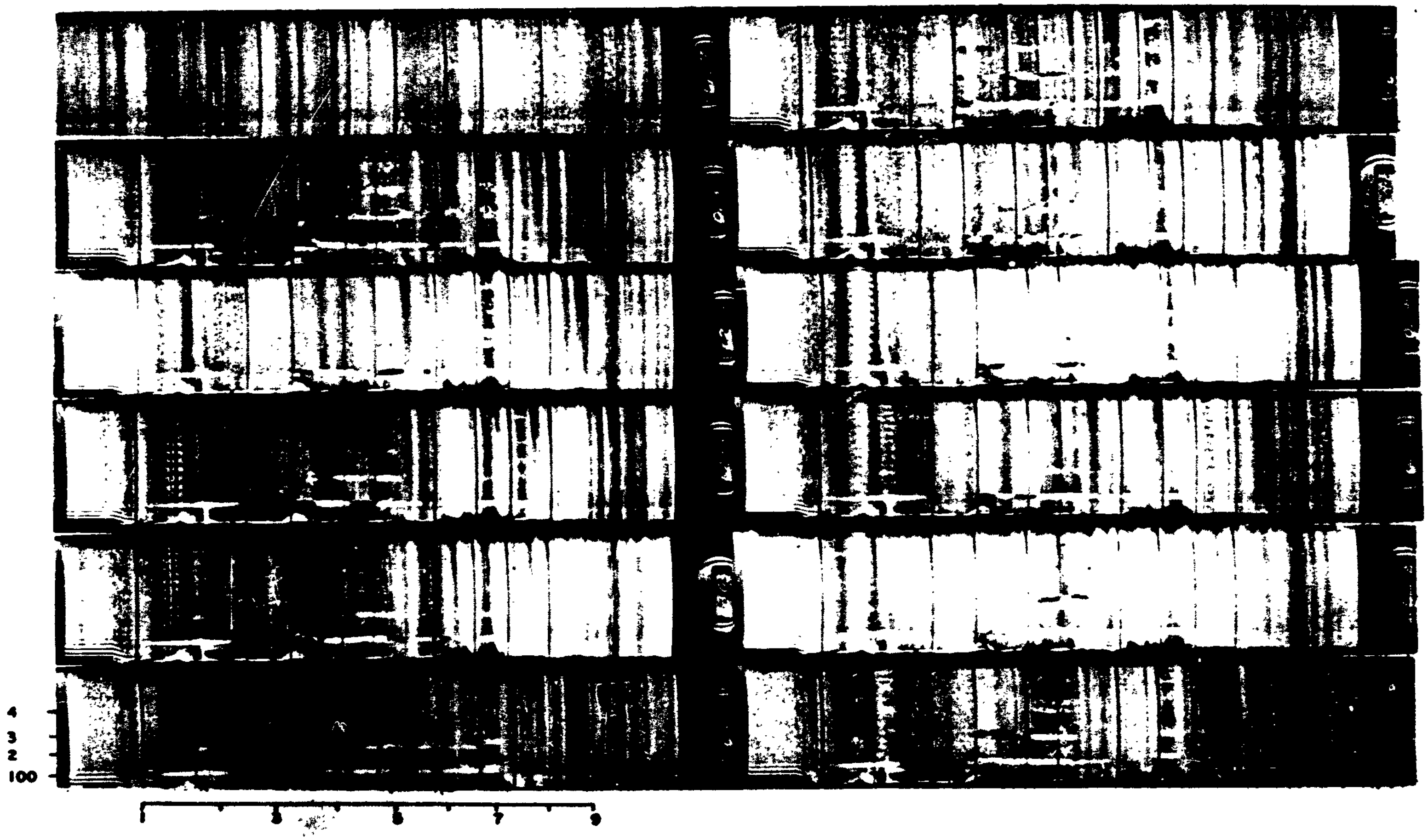
9 APR 0833 C = 0.8
9 APR 1648-1848 C = 0.8



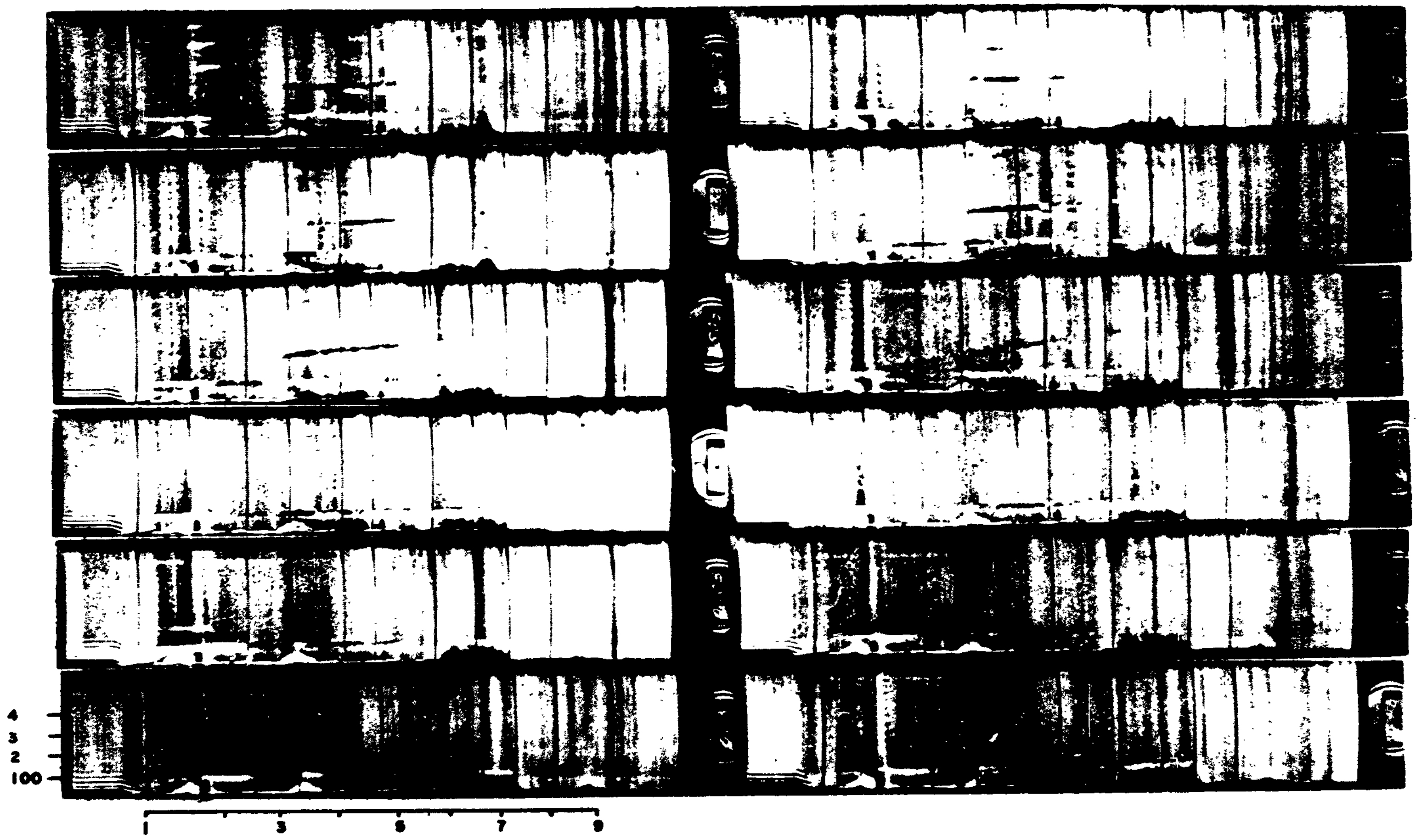
9 APR 1903 - 2148 C=0.8



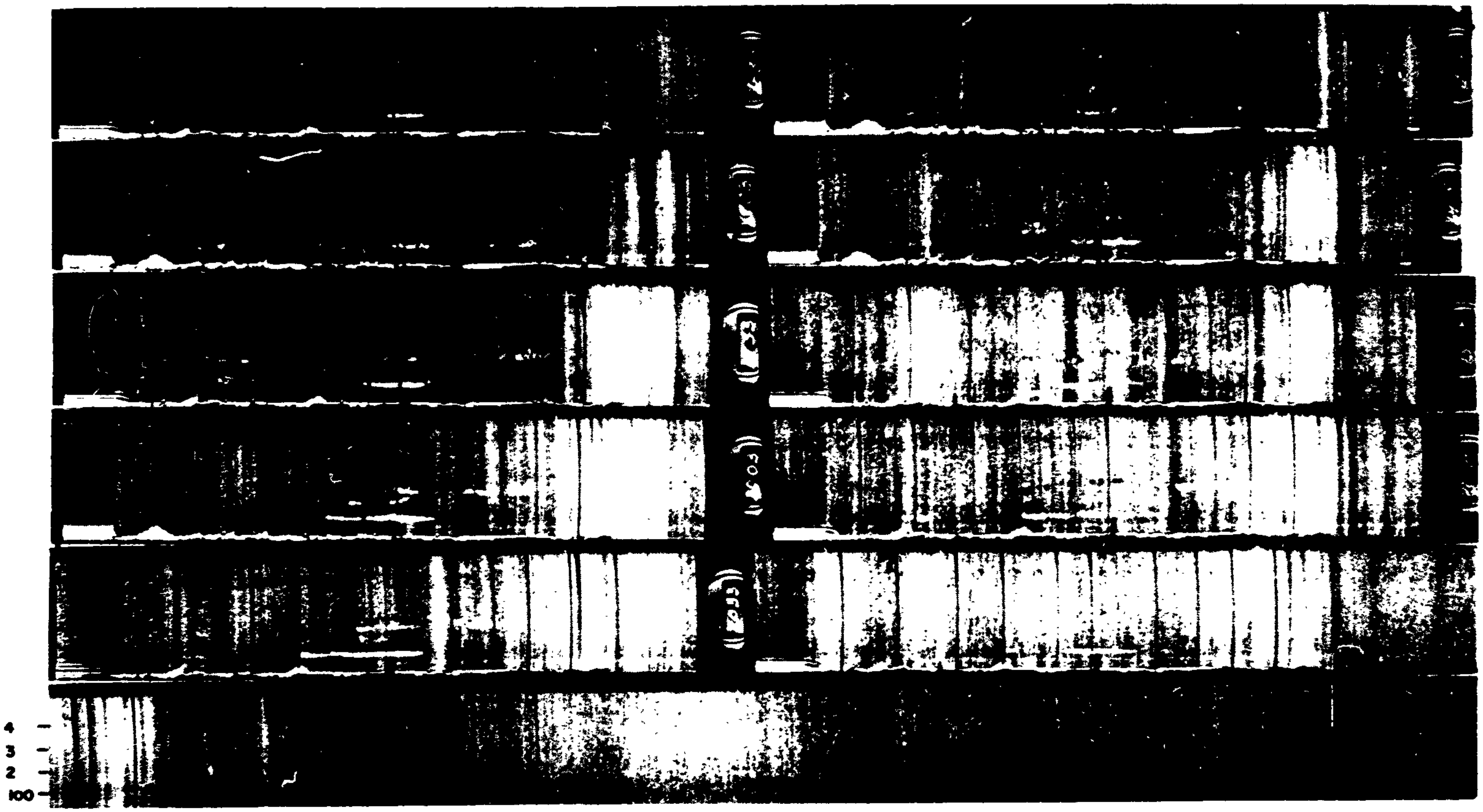
9 APR 2203-2448 C: 0.8



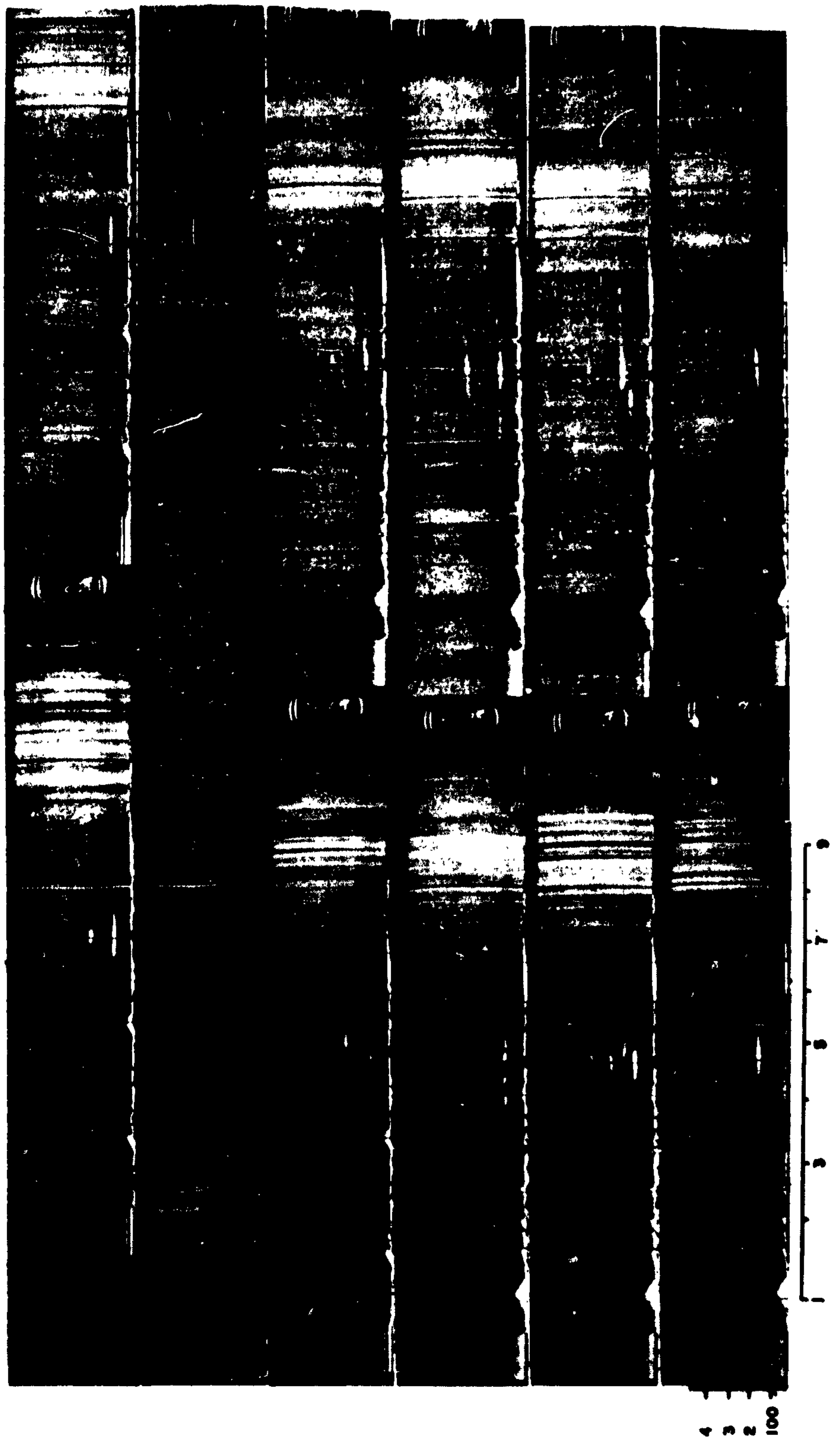
10 APR 0107 - 0348 C= 1.4



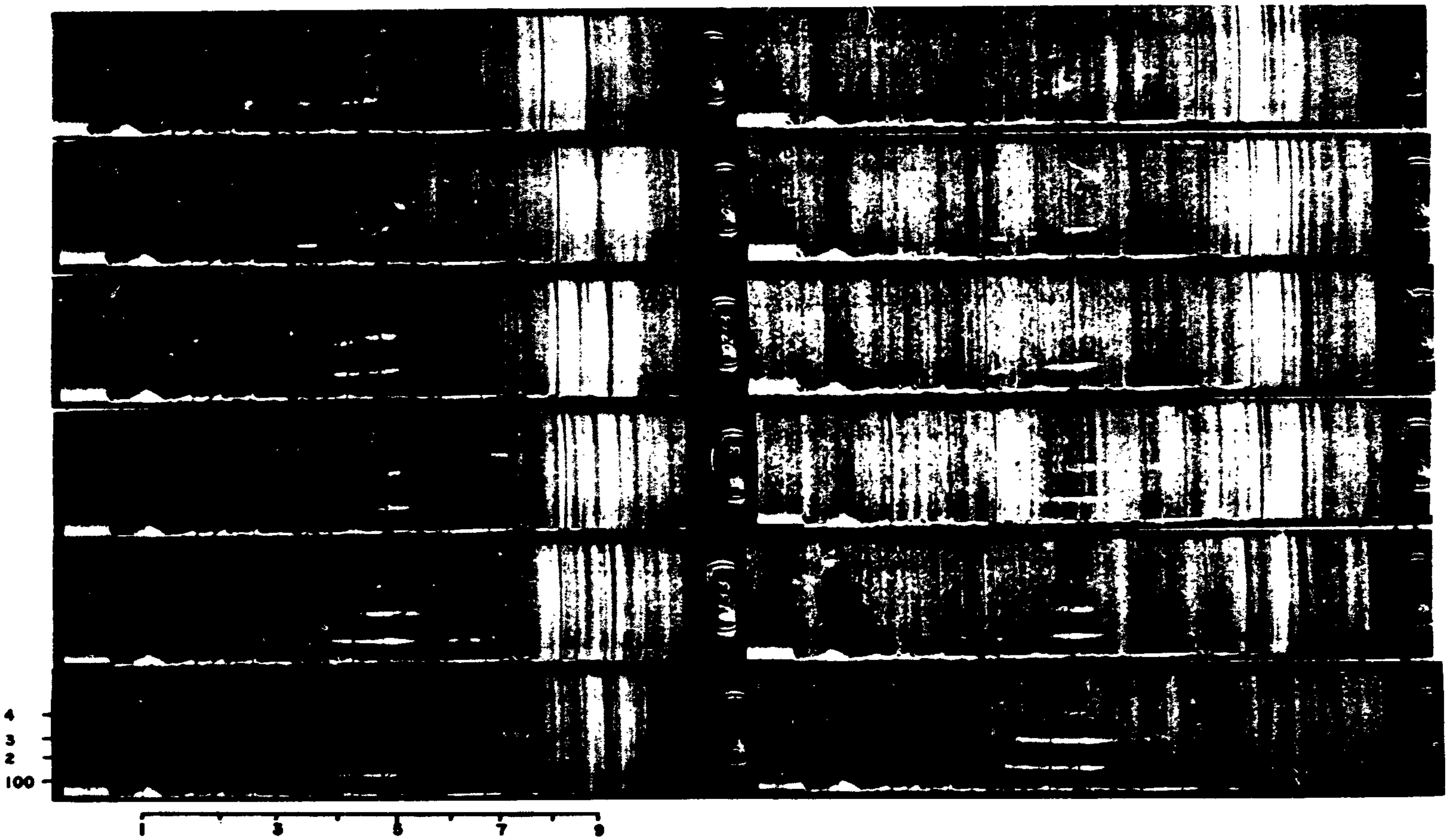
10 APR 0403 - 0648 C = 1.4



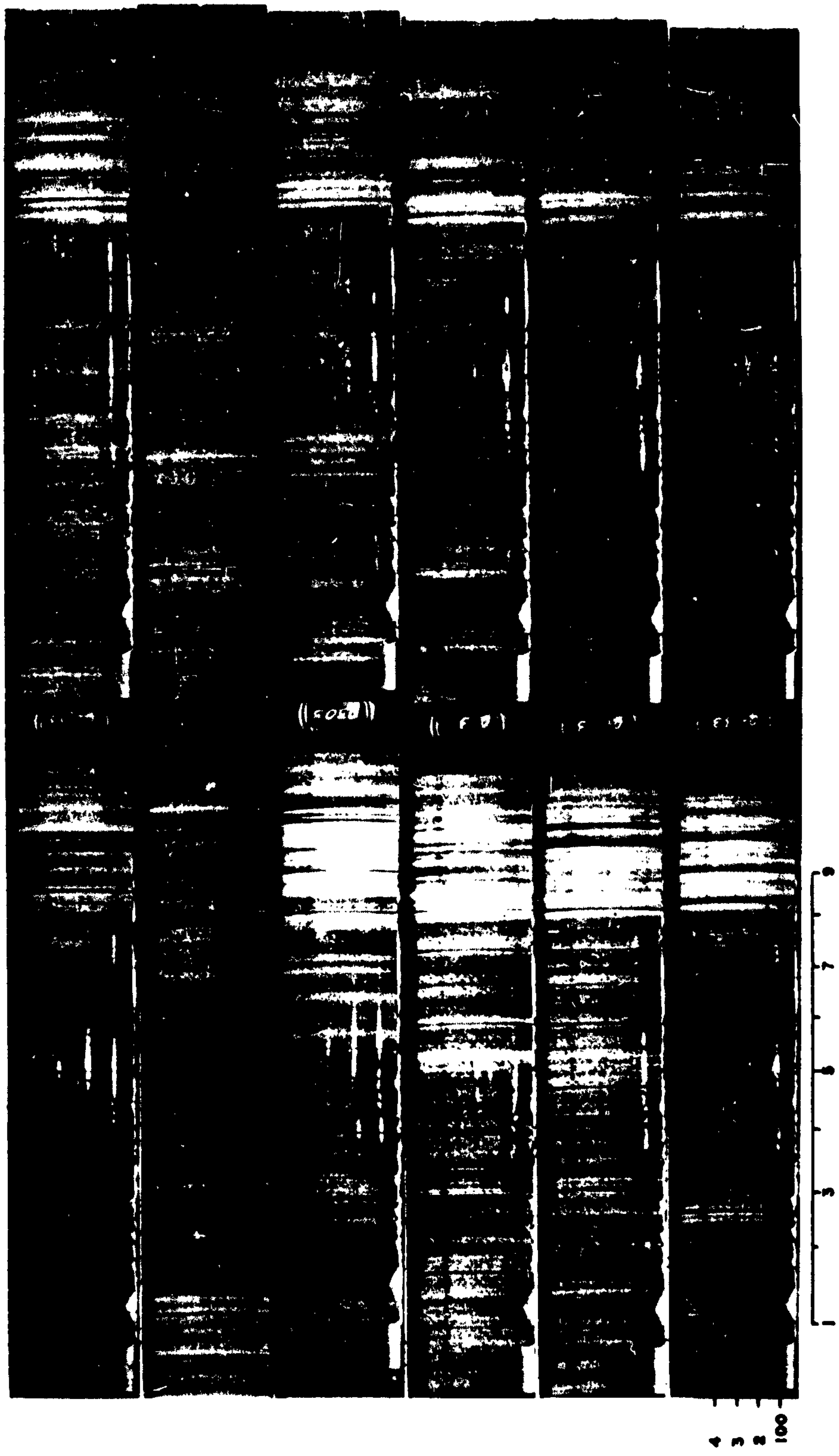
10 APR 1833 - 2048 C = 1.4



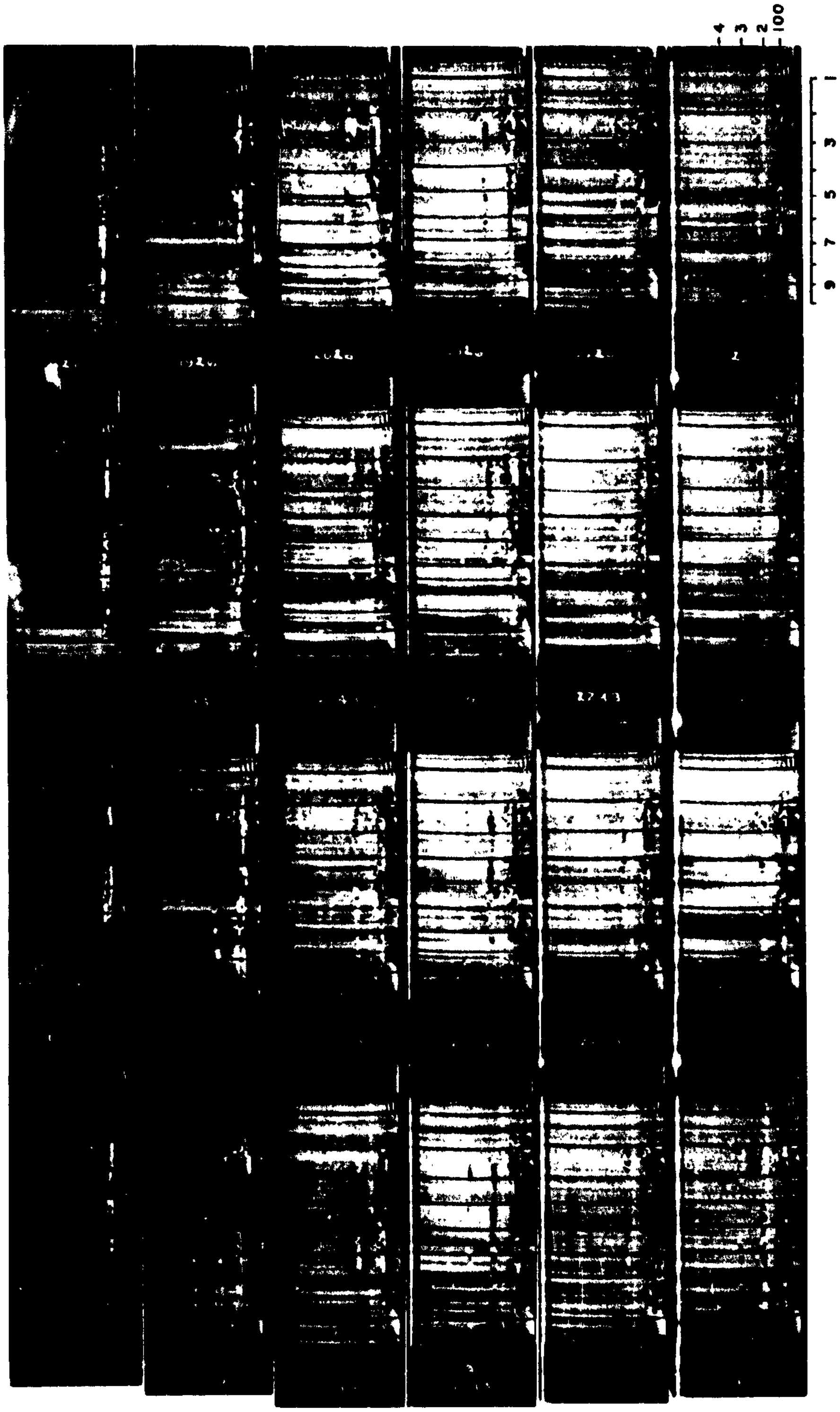
10 APR 2103-2318 C= 1.4



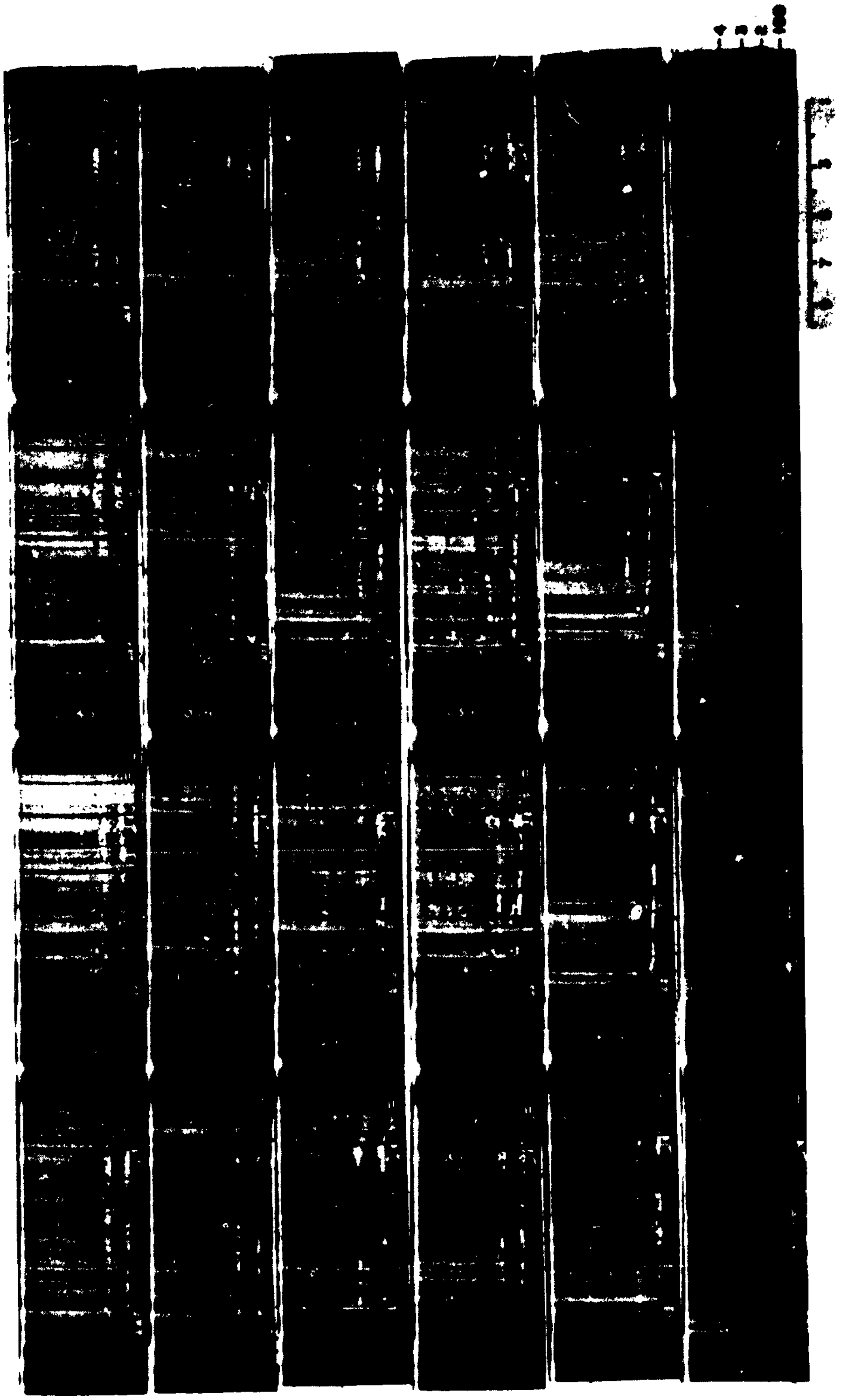
10 APR 2333 - 2348 C = 1.4
11 APR 0003 - 0218 C = 1.1



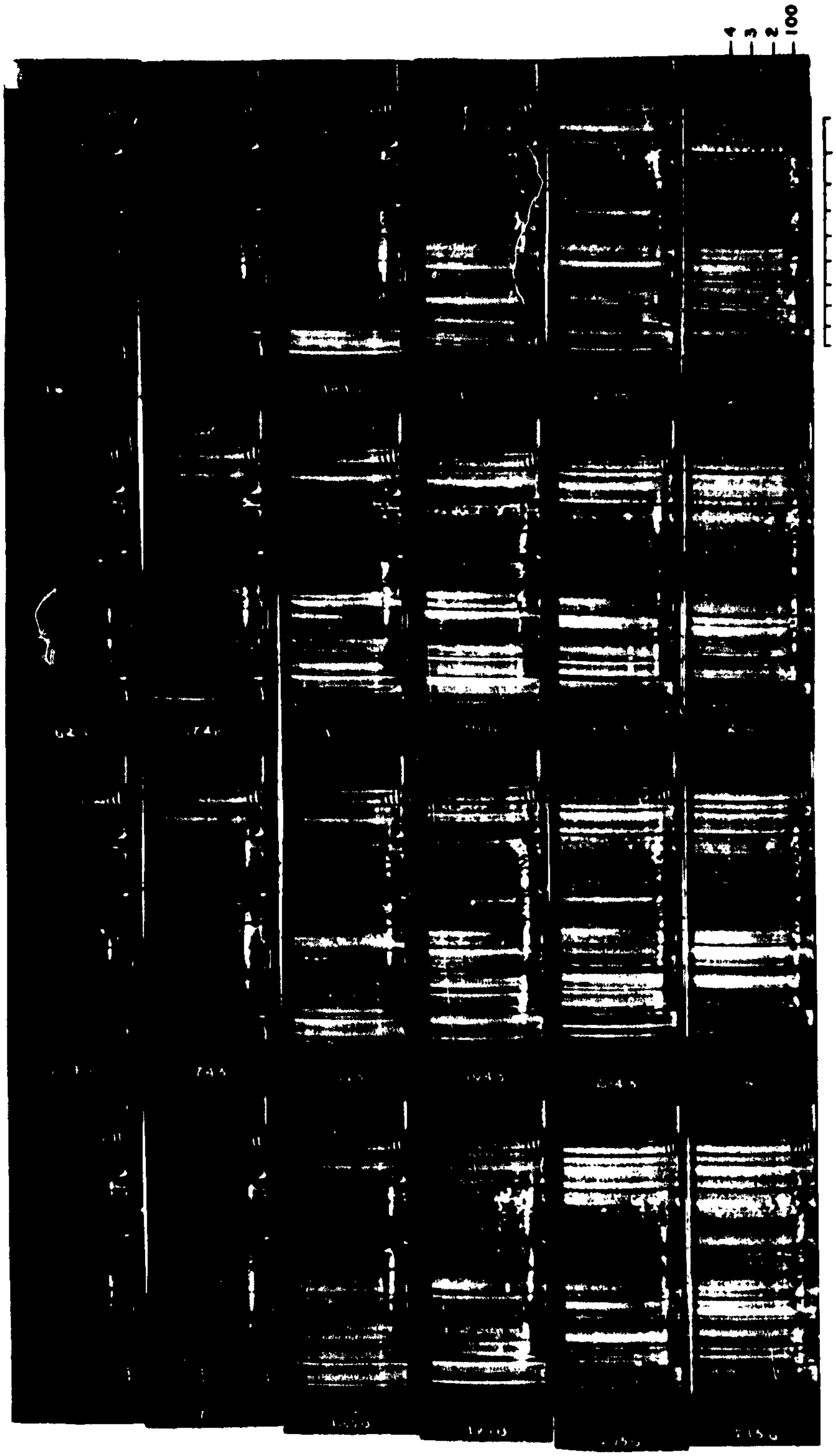
11 APR 0233 - 0448 C = 1.1



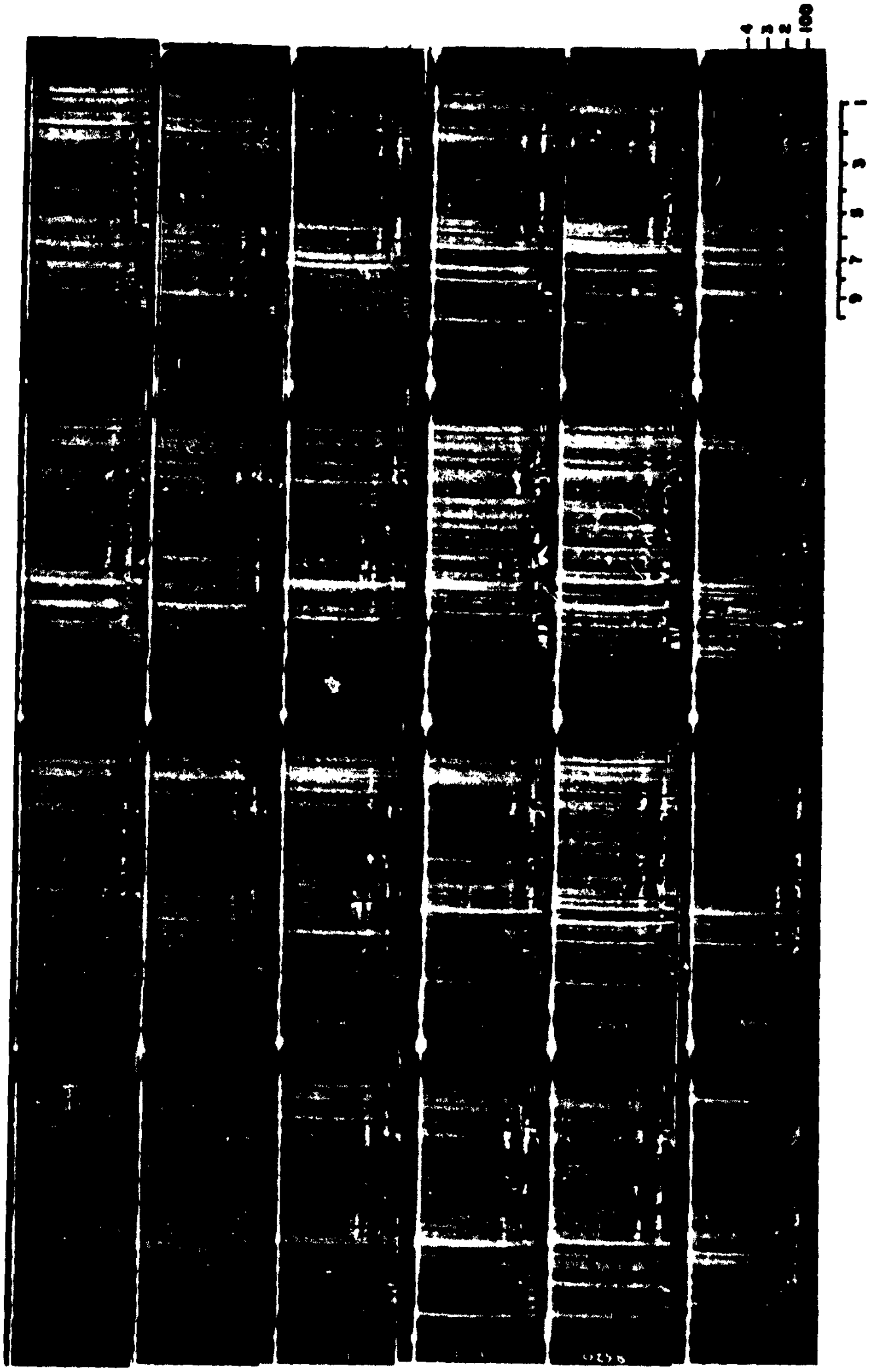
17 MAY 1828 - 2358 C= 0.1
18 MAY 0013 C=0.0



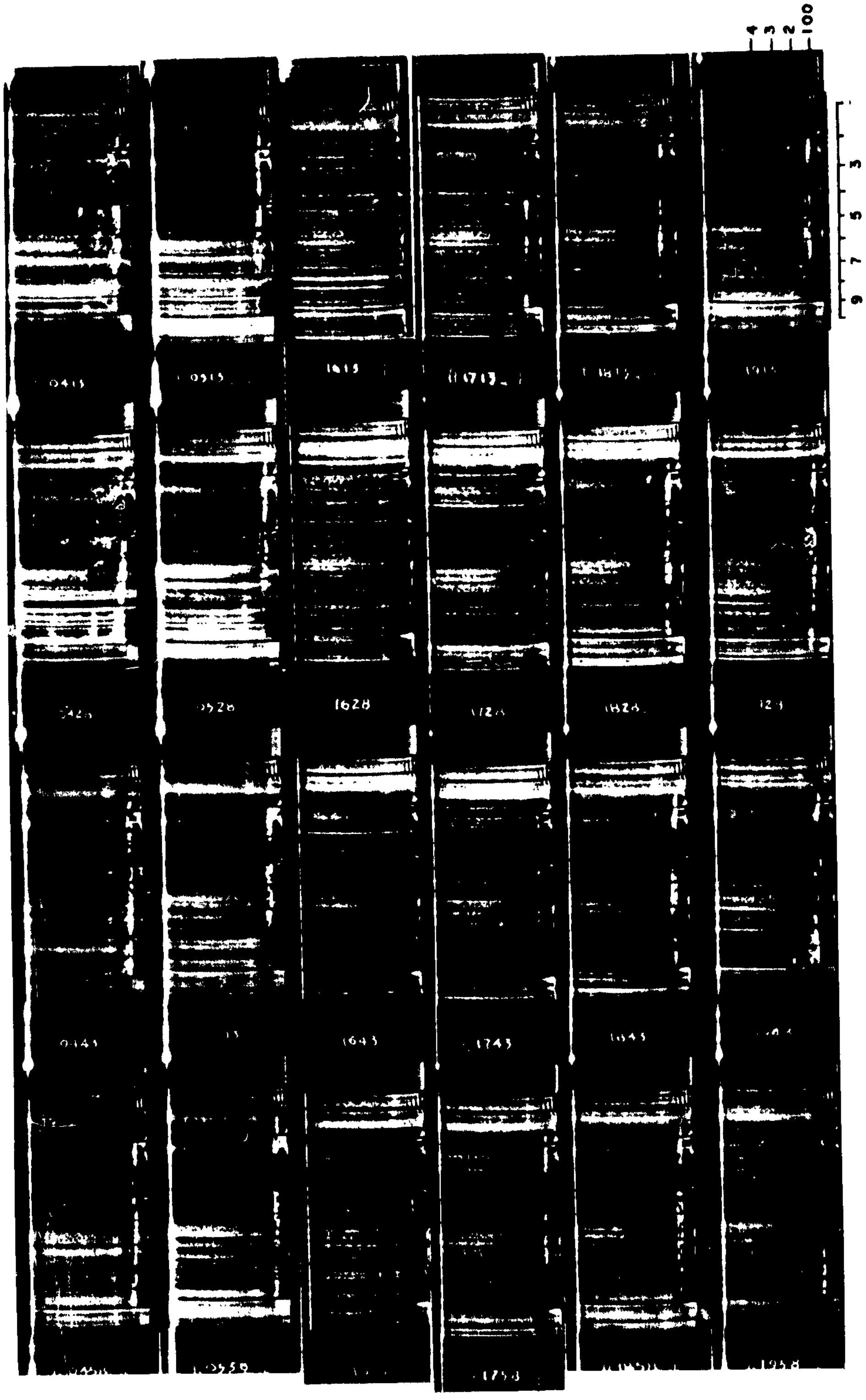
18 MAY 0028-0613 C=0.0



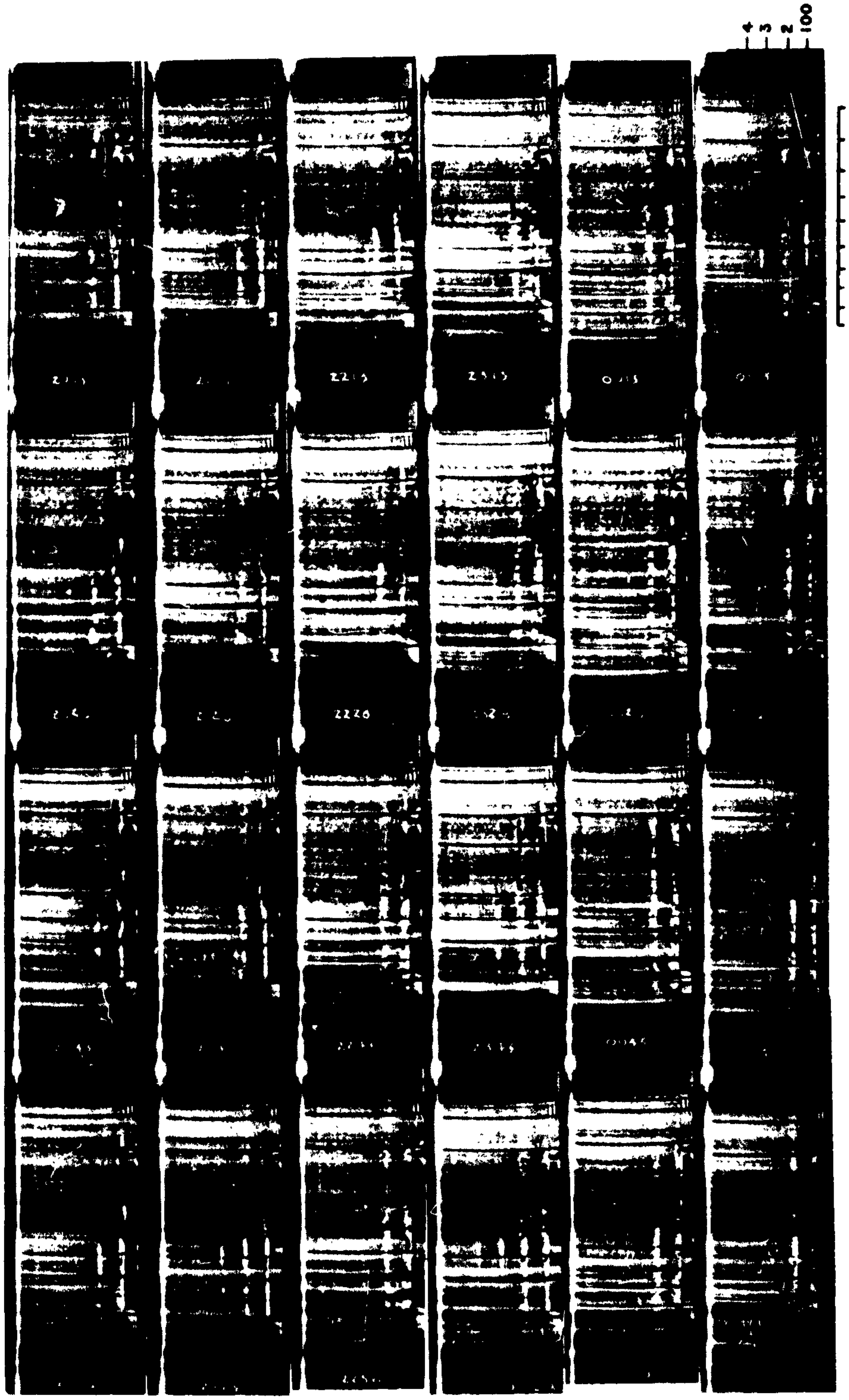
18 MAY 1613-2158 C=0.0



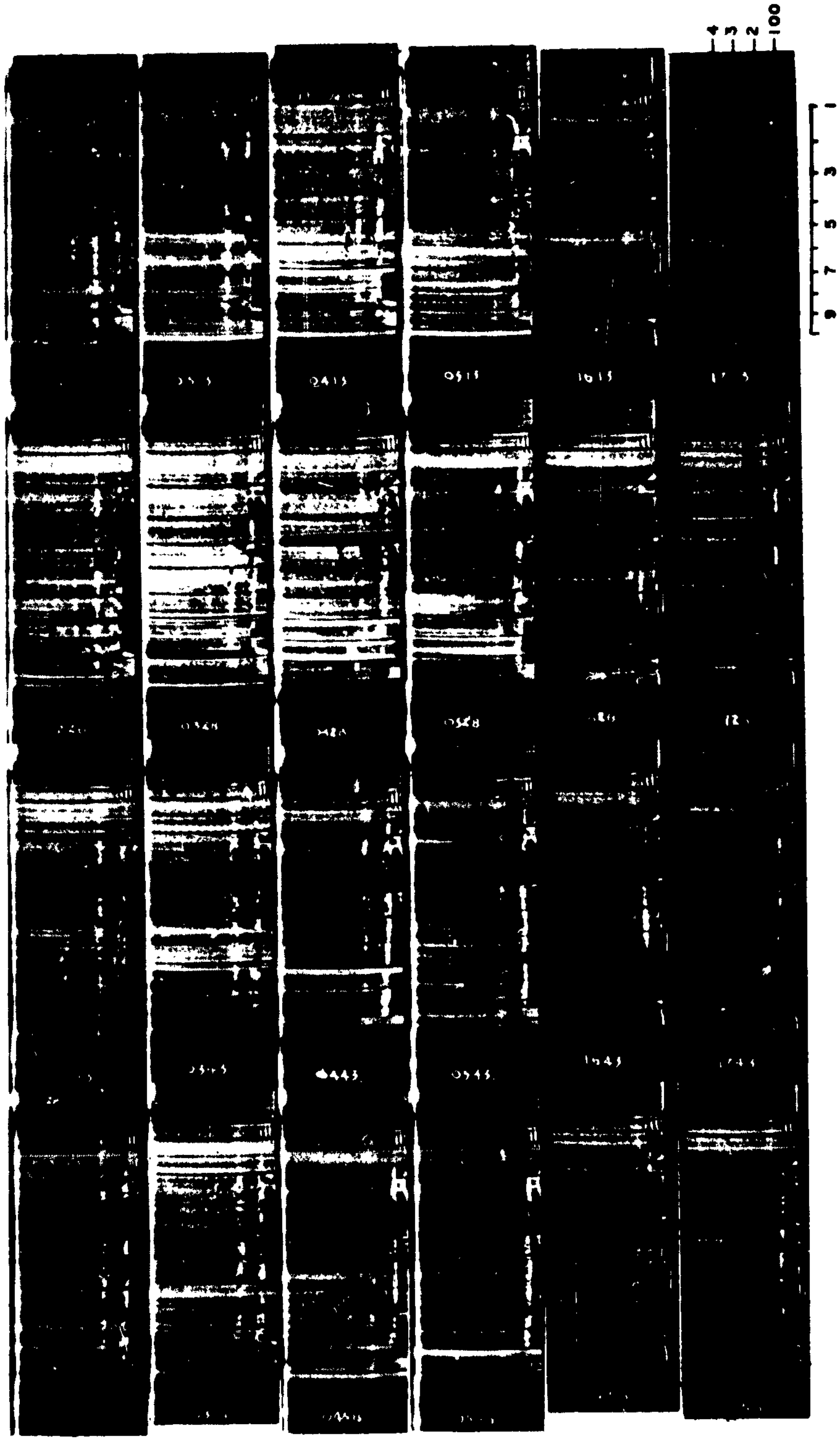
18 MAY 2213-2358 C=0.0
19 MAY 0013-0358 C=0.6



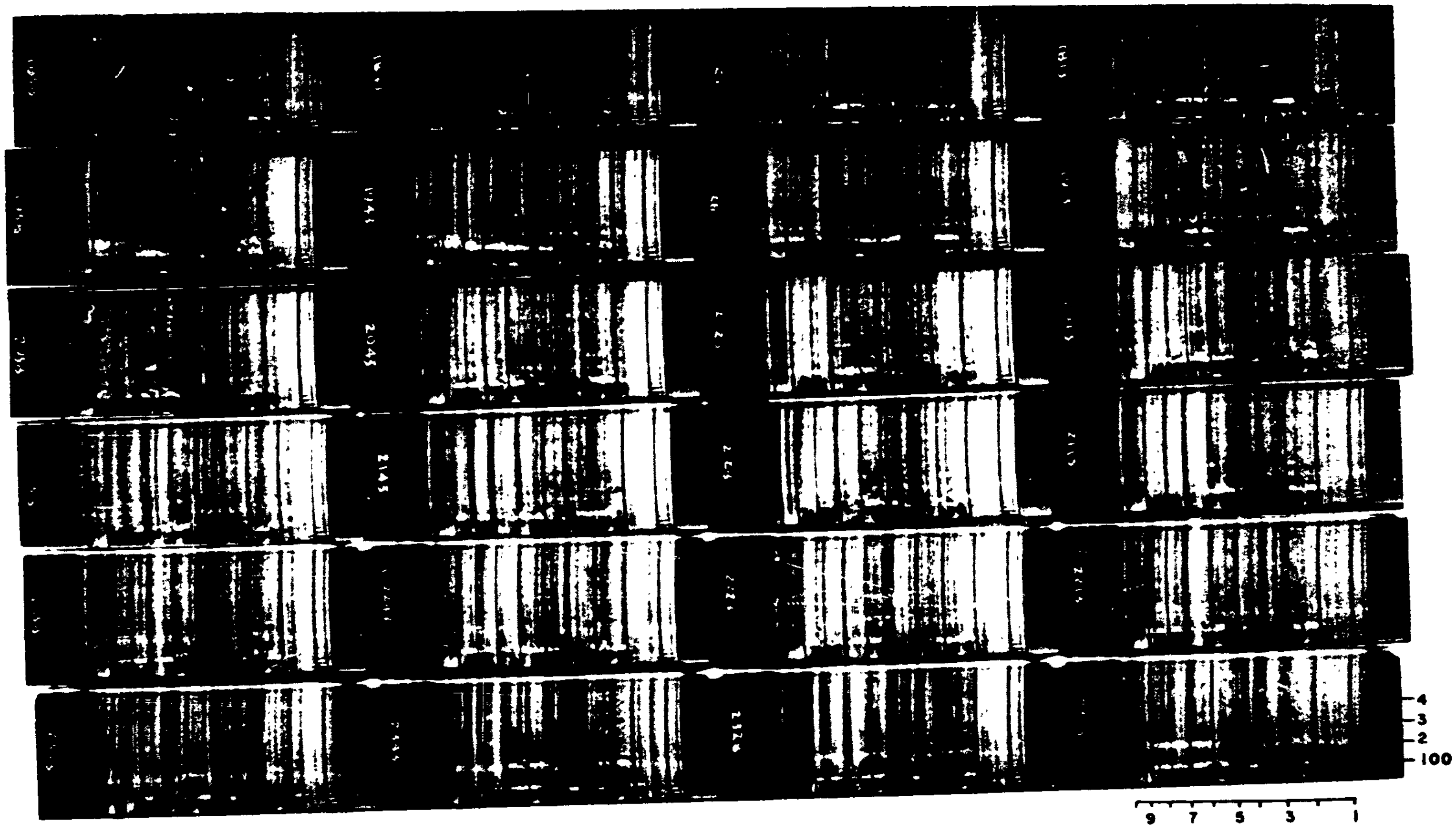
19 MAY 0413-0558 C=0.6
19 MAY 1613-1958 C=0.6



19 MAY 2013–2358 C=0.6
20 MAY 0013–0158 C=0.3



20 MAY 0213-0558 C=0.3
20 MAY 1613-1758 C=0.3


2045
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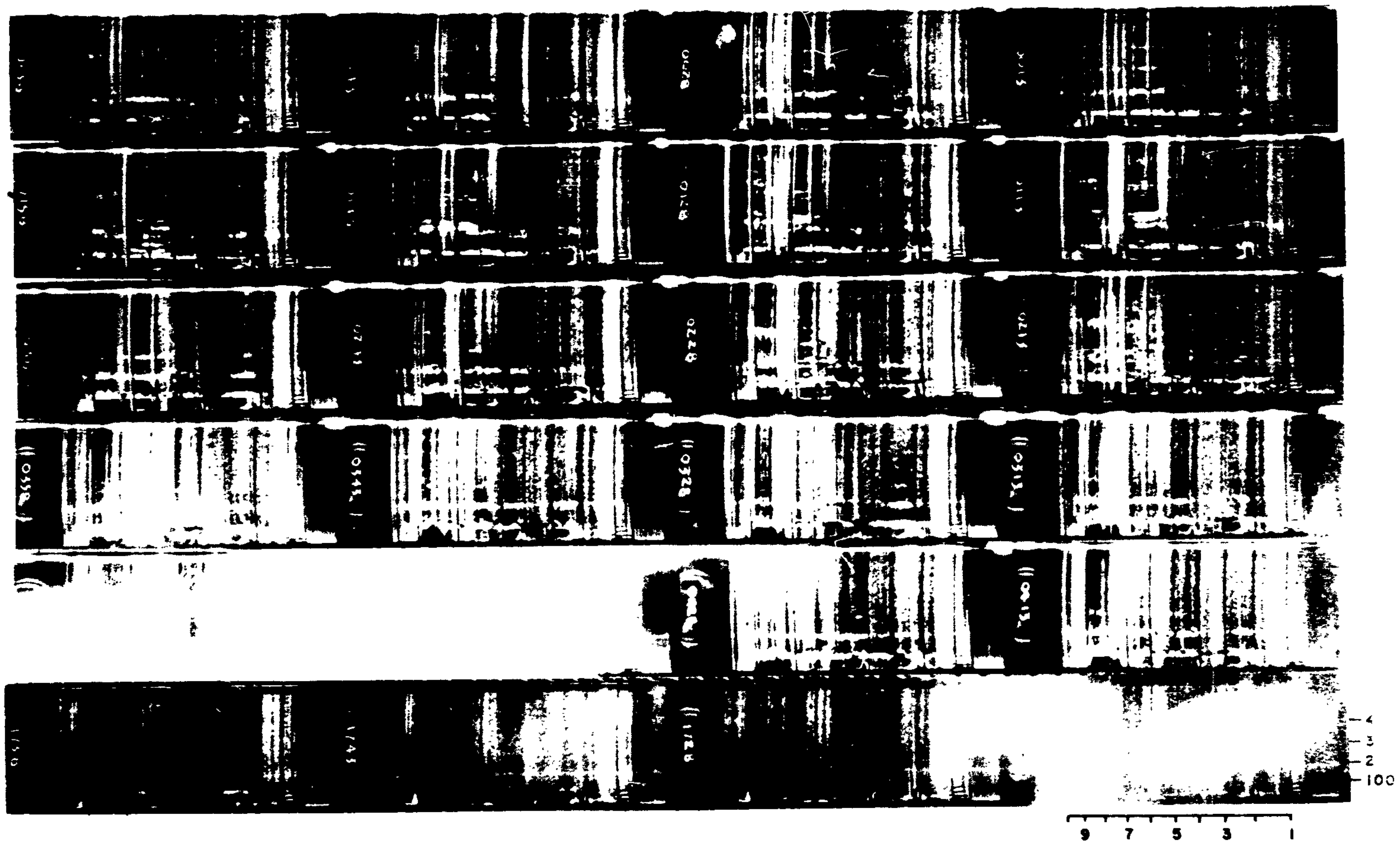
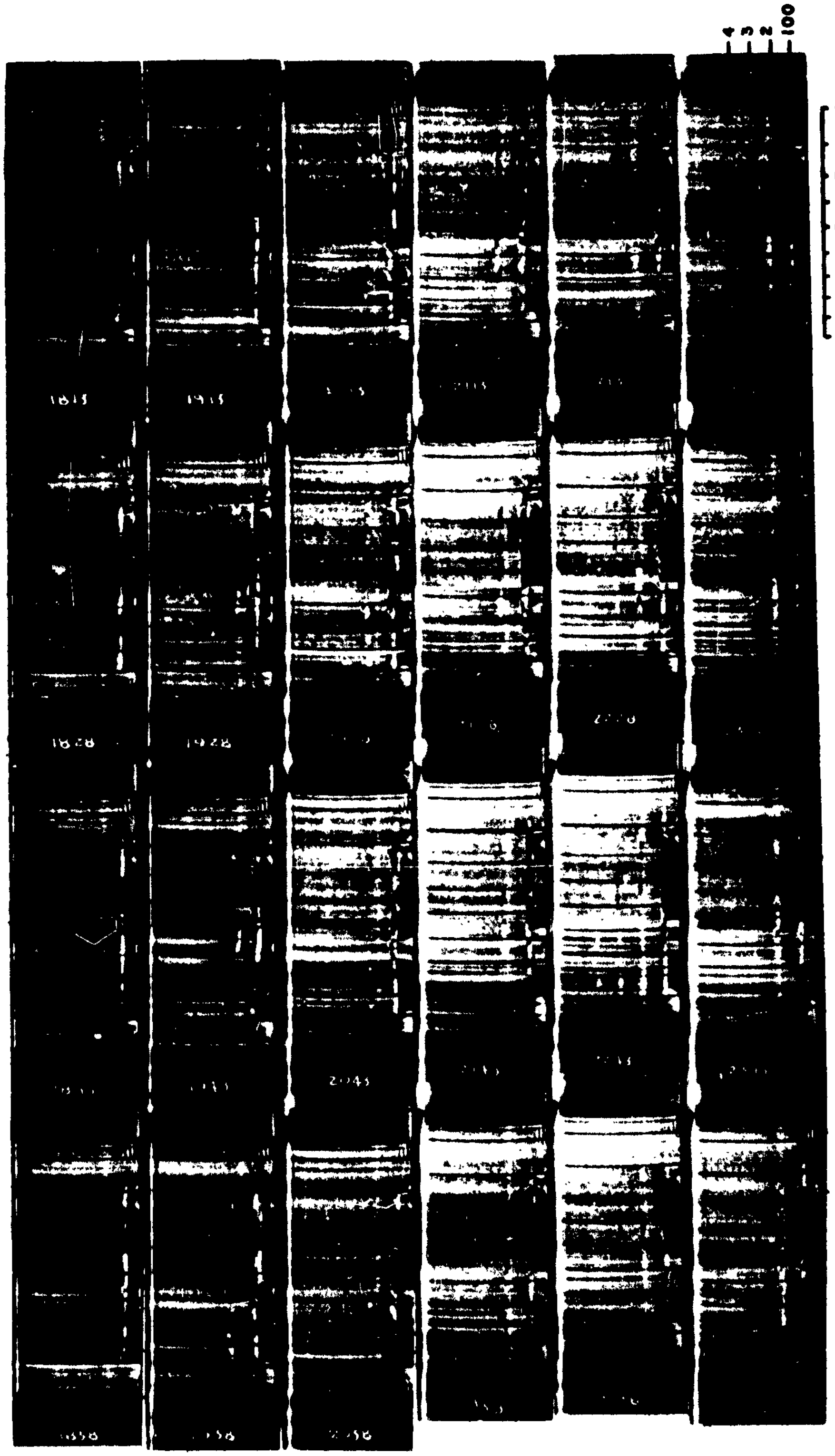
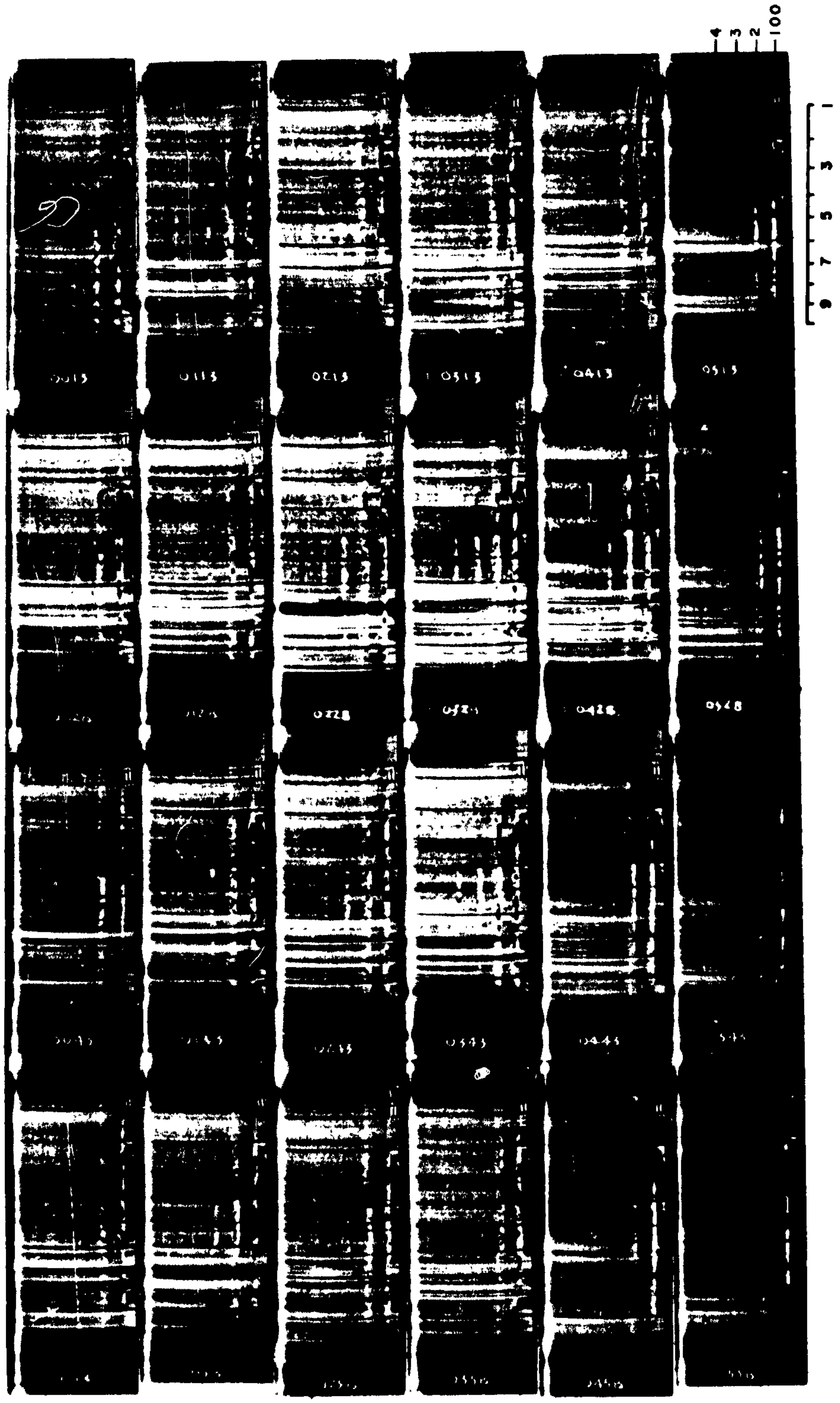
20 MAY 1813-2358 C=0.3



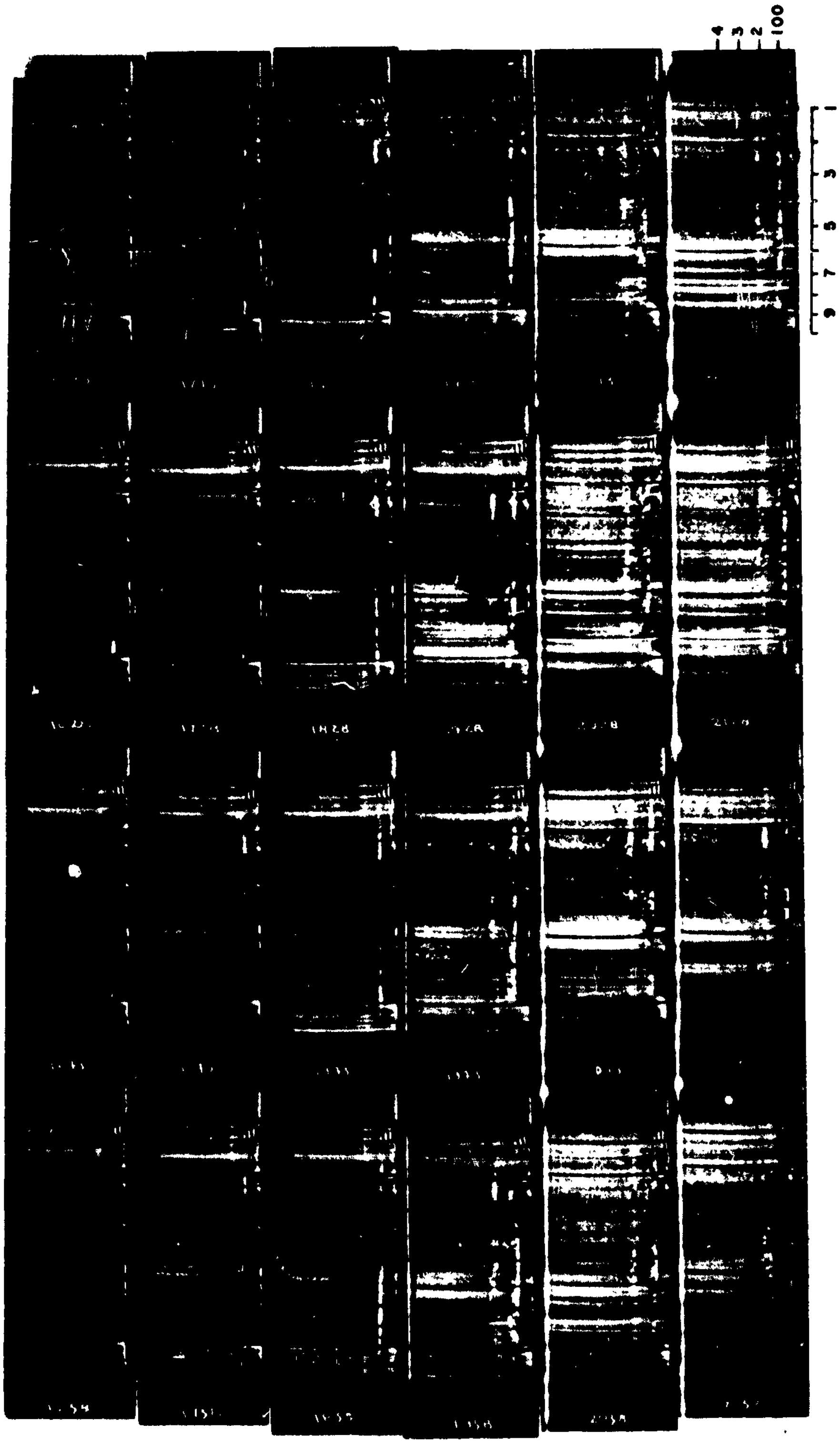
21 MAY 0013-0558 C=0.0



21 MAY 1813–2358 C=0.0

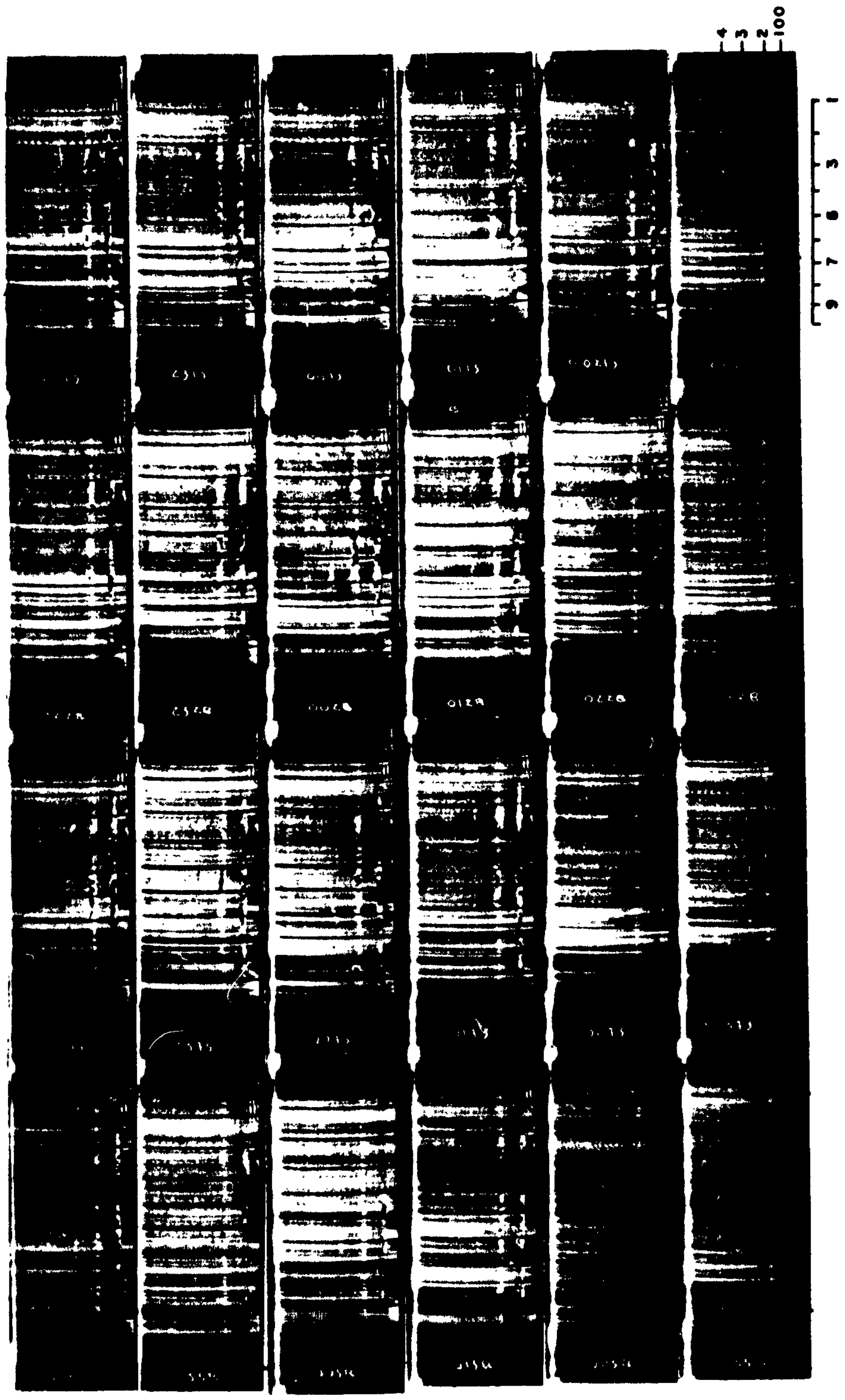


22 MAY 0013-0558 C=0.0

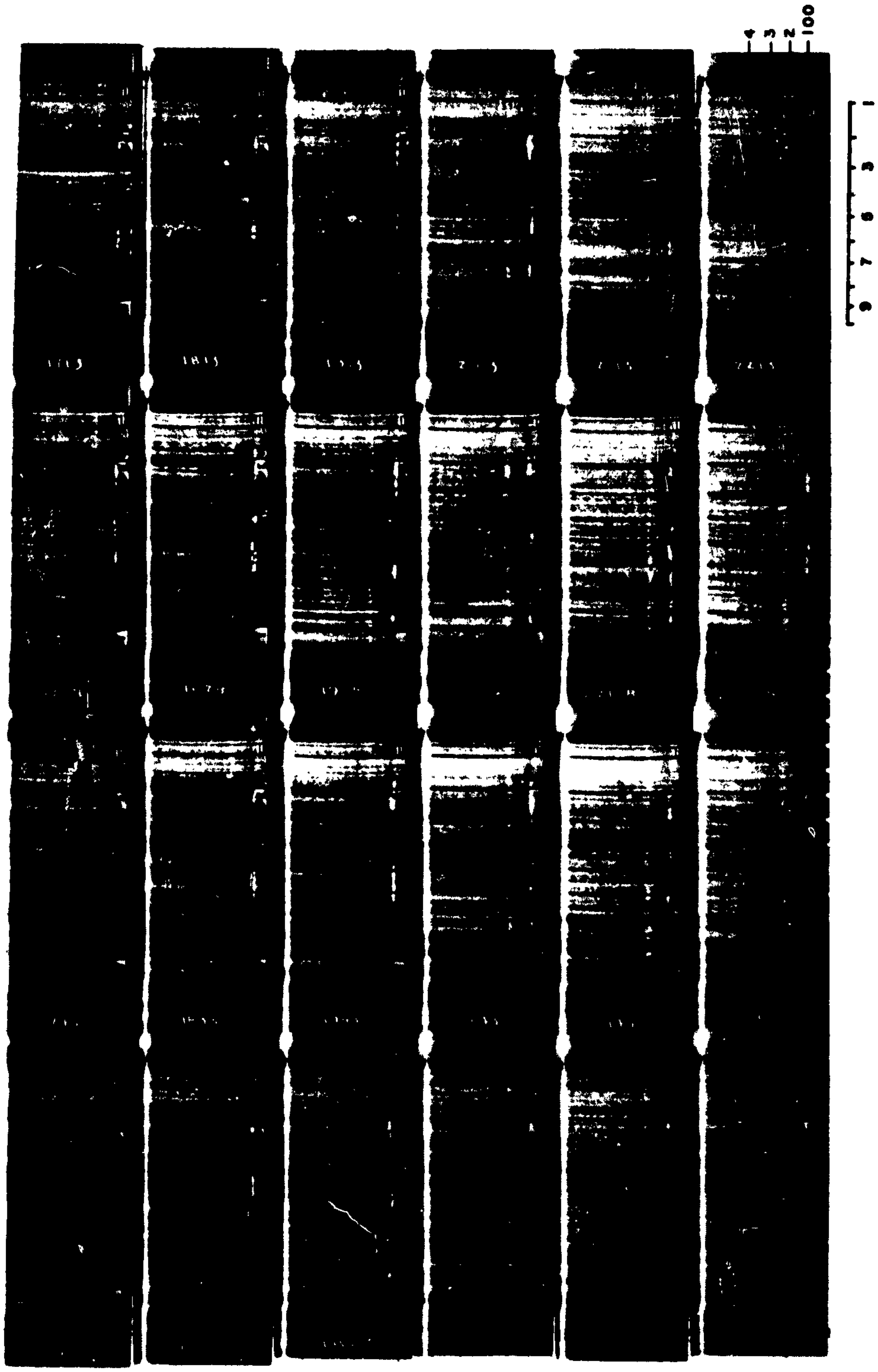


22 MAY 1613-2158

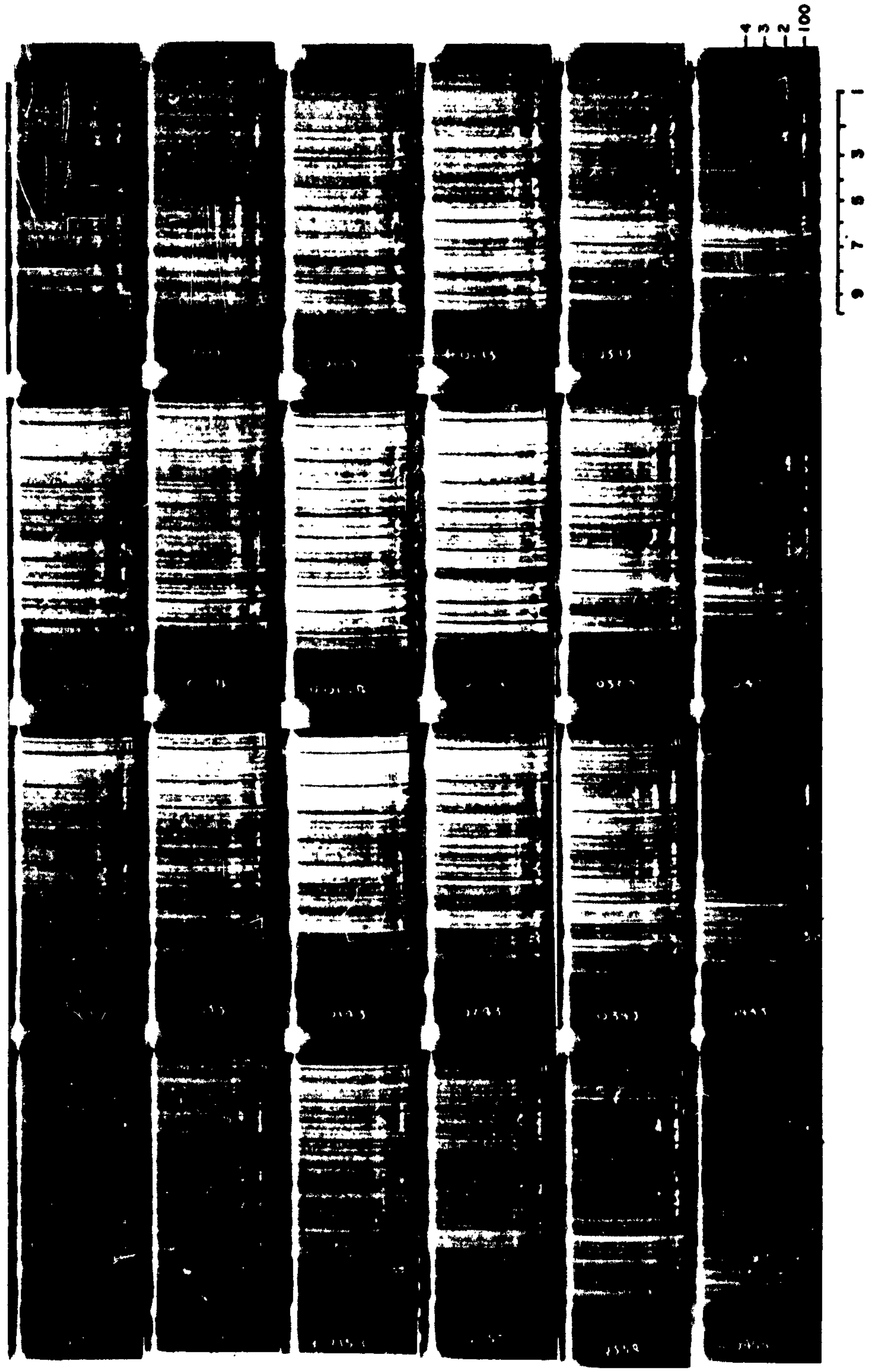
C=0.0



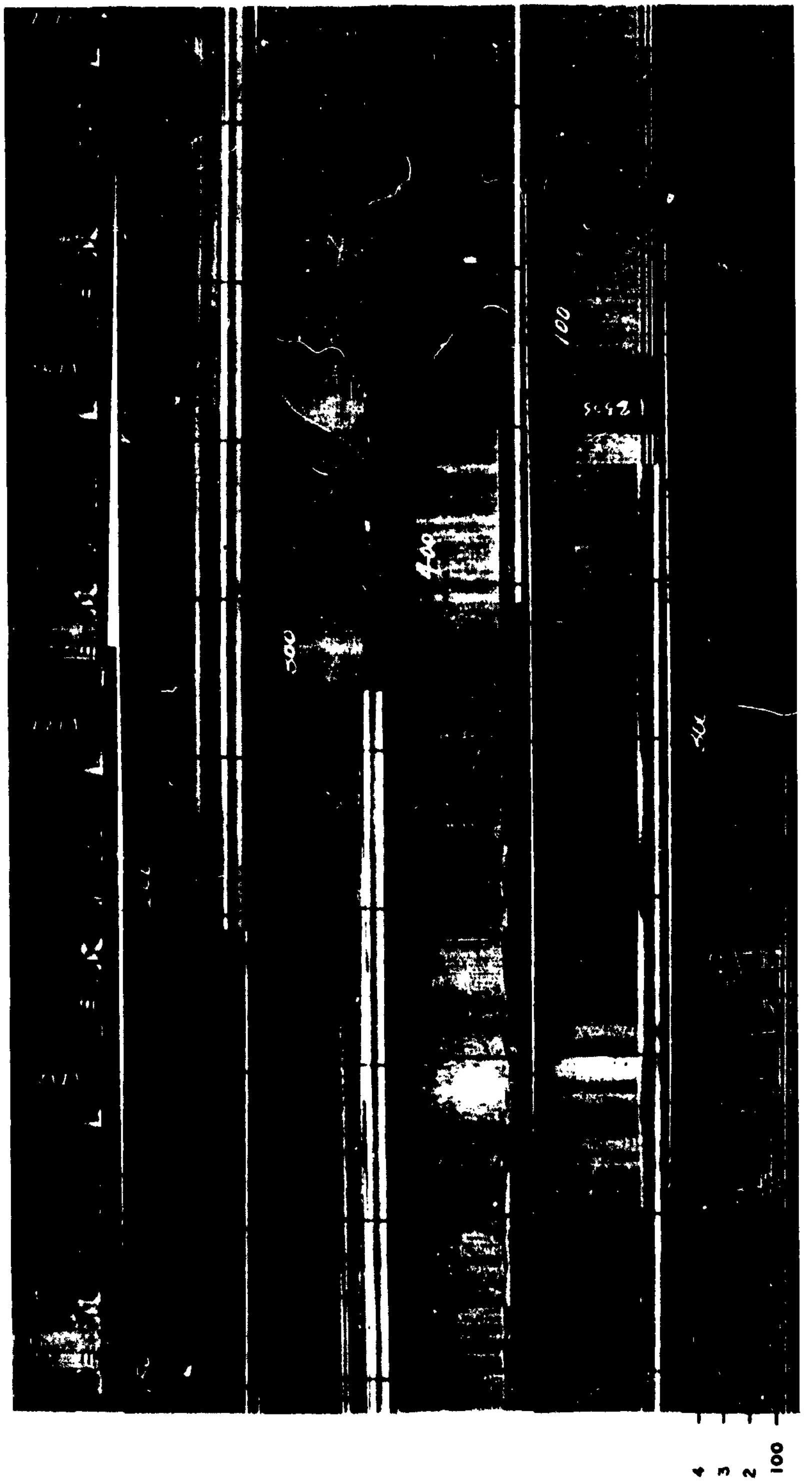
22 MAY 2213-2358 C=0.0
23 MAY 0013-0358 C=0.0



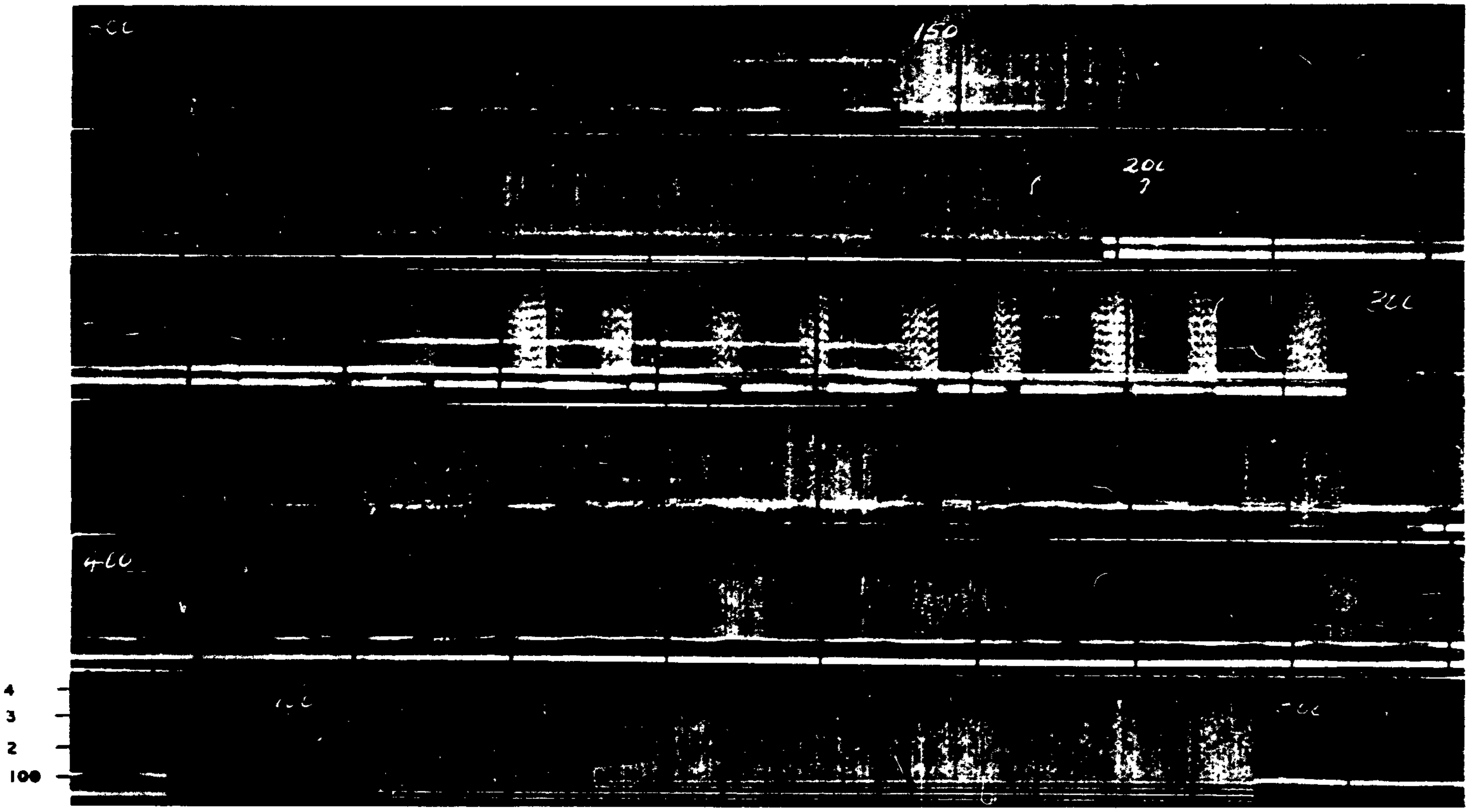
23 MAY 1713-2258 C=0.0



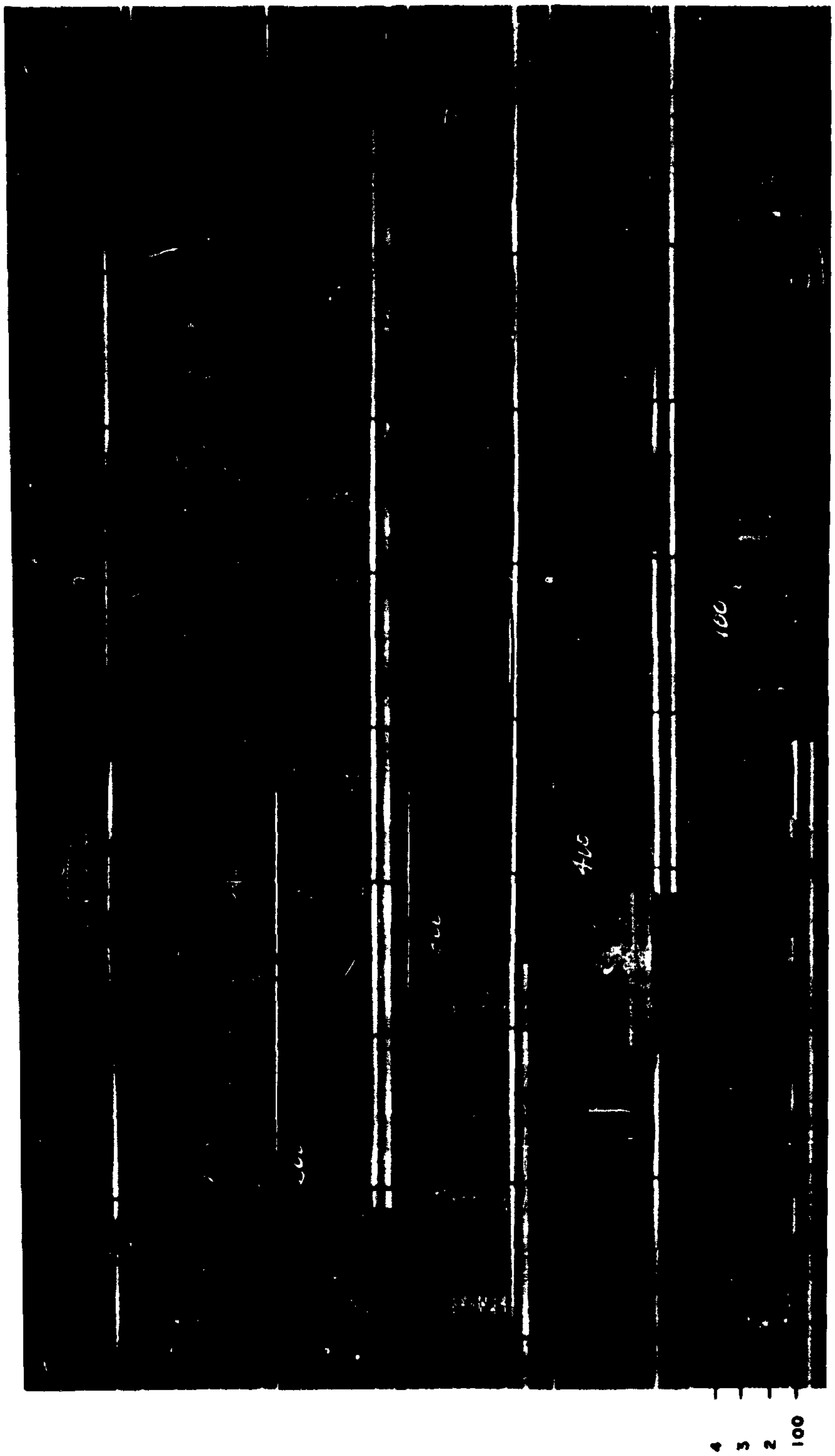
23 MAY 2313-2358 C=0.0
24 MAY 0013-0458 C=0.0



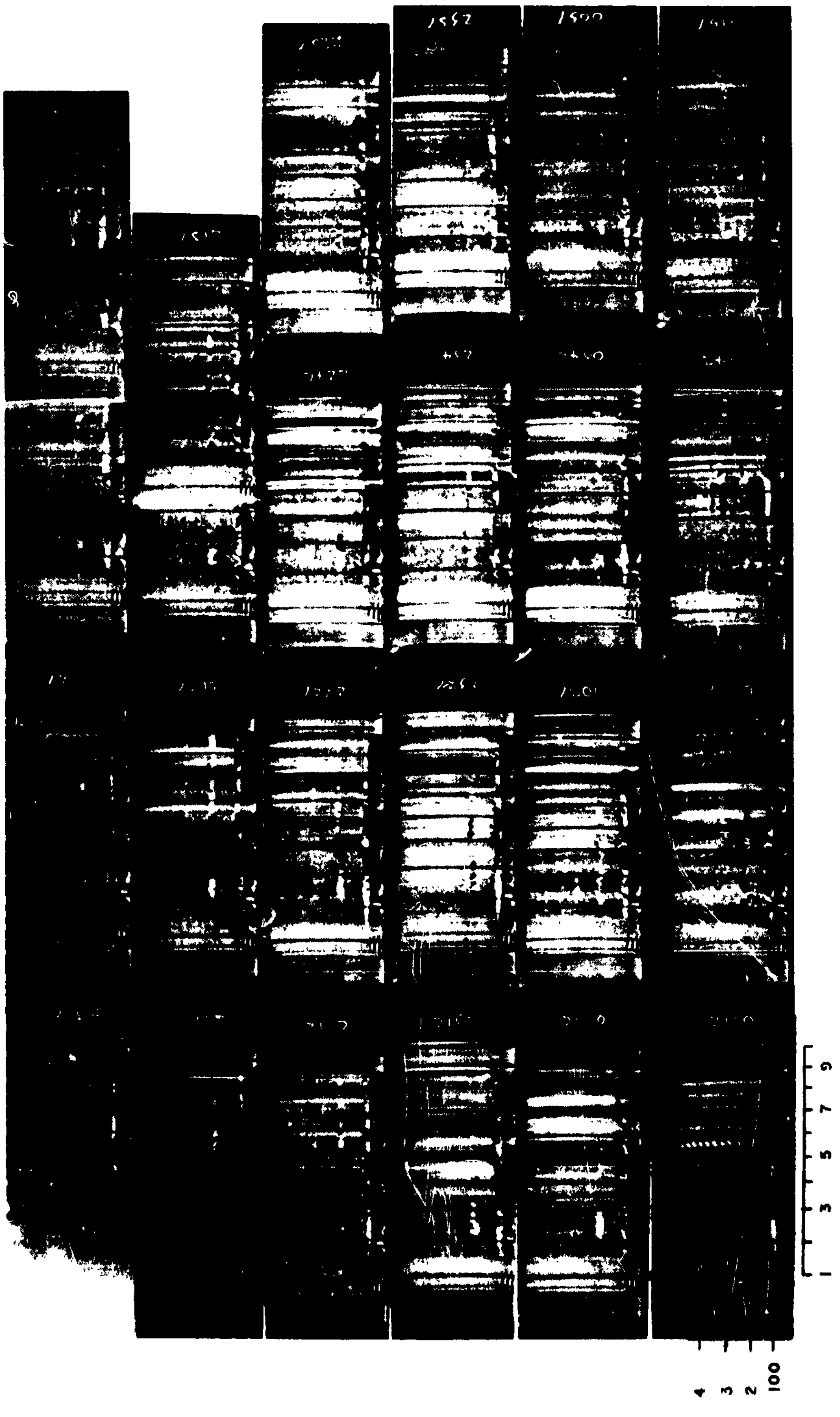
25 MAY 1712 - 1757 C=0.0
25 MAY 2230 - 2314 C=0.0



25 MAY 2315 - 2359 C = 0.0
26 MAY 0001 - 0010 C = 0.1



26 MAY 0011 - 0107 C=0.1



28 MAY 2012 - 2357 C = 0.4
29 MAY 0012 - 0157 C = 0.3

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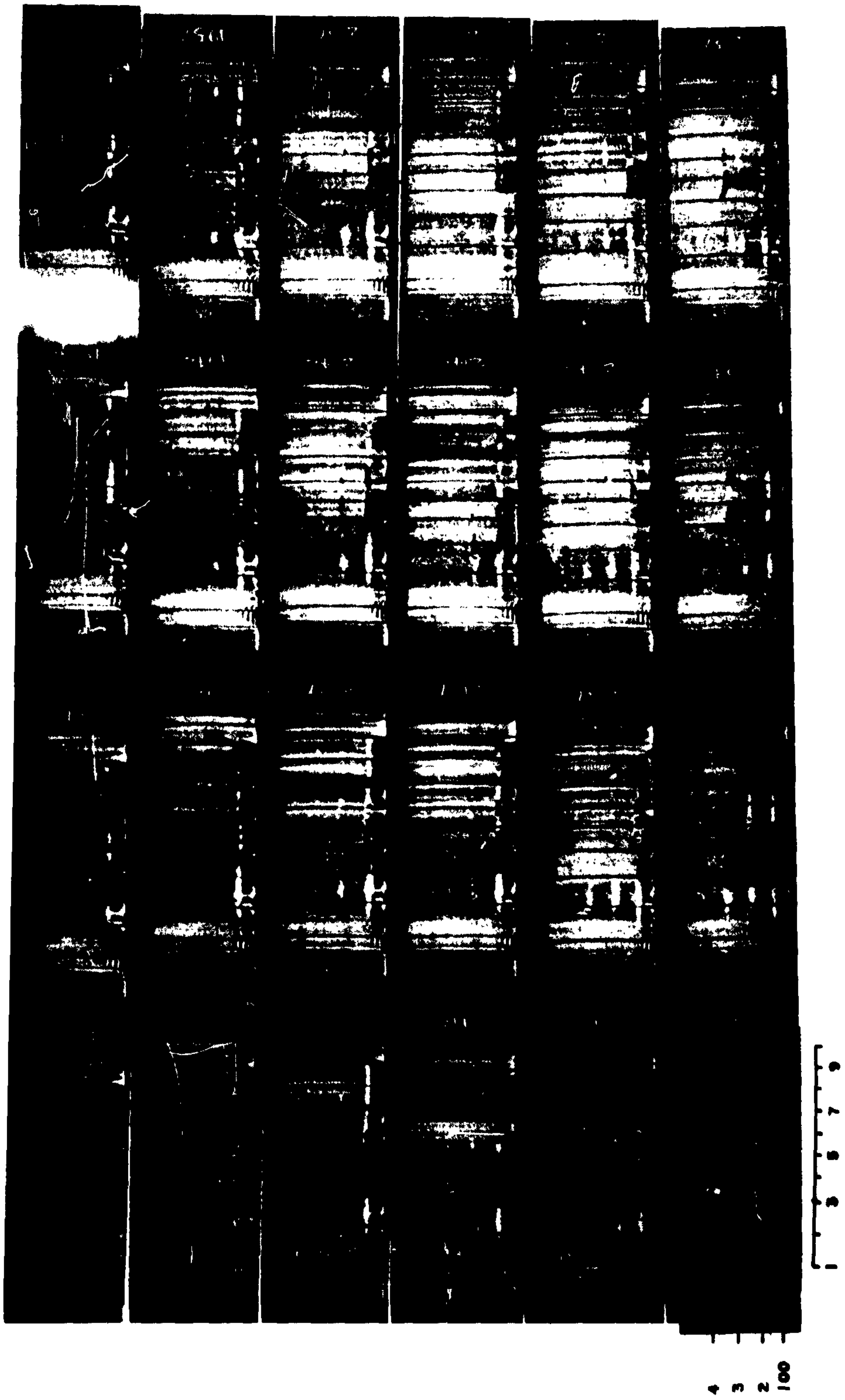
29 MAY 0212 - 0557 C=.0.3
29 MAY 1612 - 1757 C=0.3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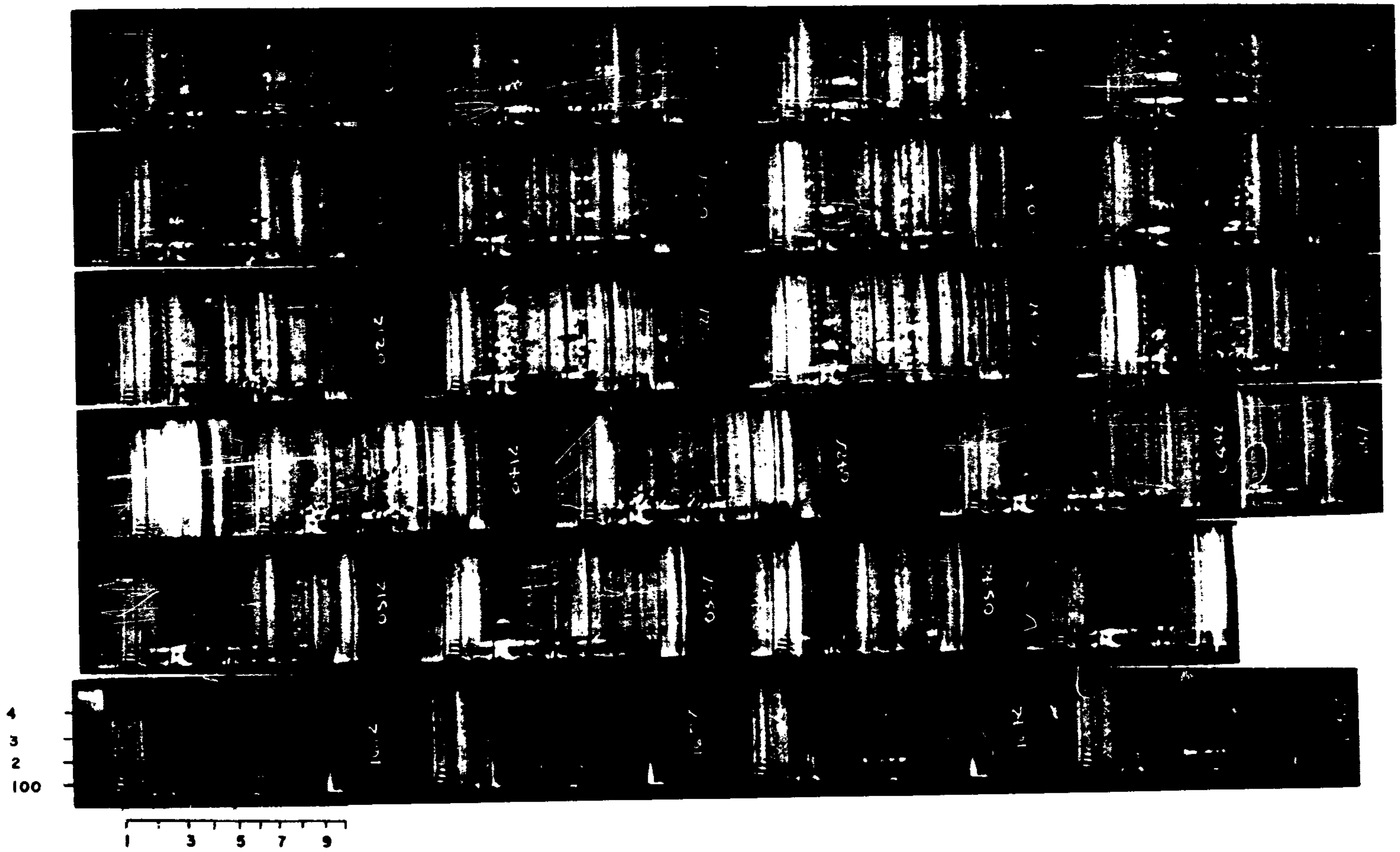
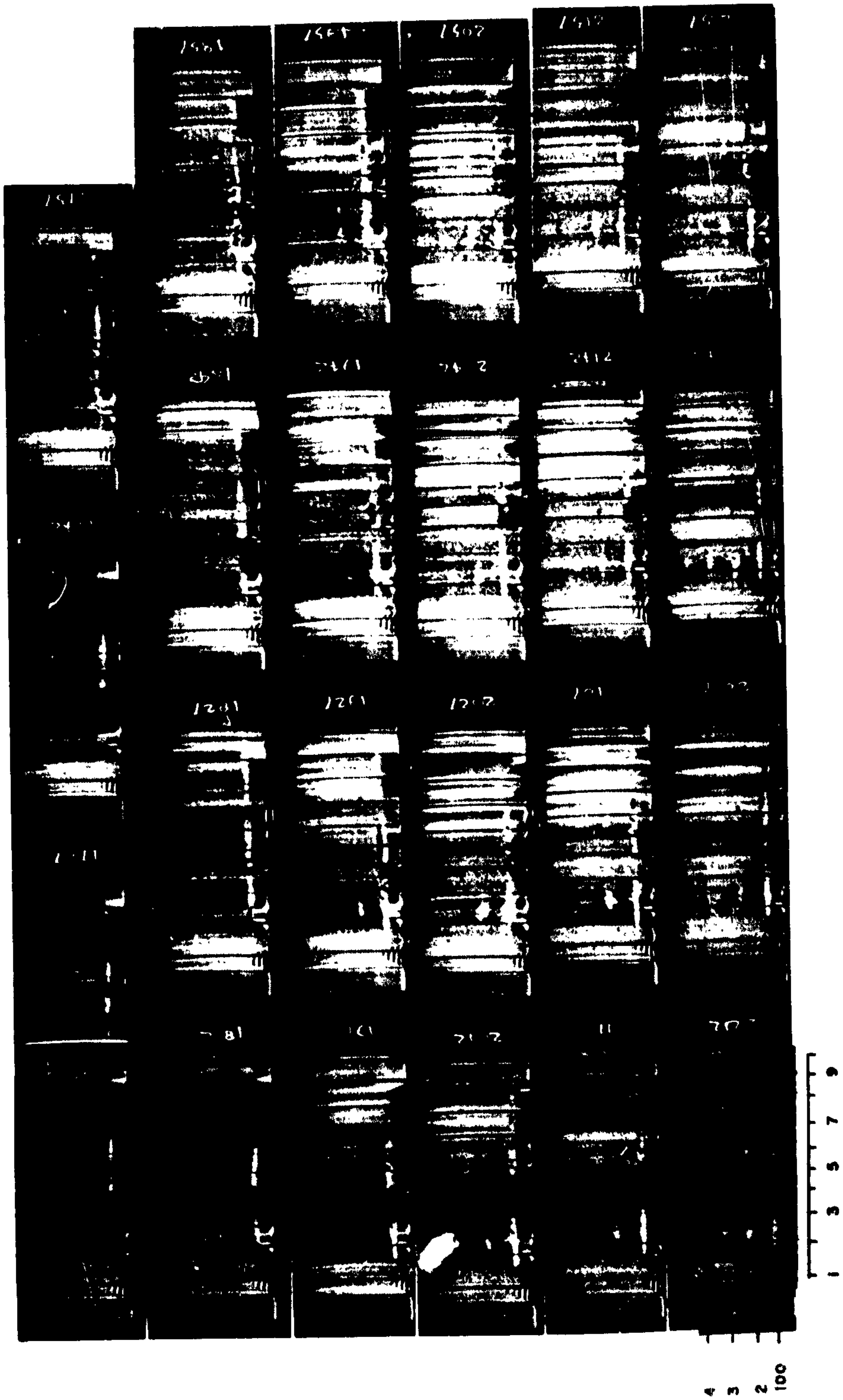
29 MAY 1812 - 2357 C = 0.3



30 MAY 0012 - 0557 C=0.1
30 MAY 1612 - 1657 C=0.1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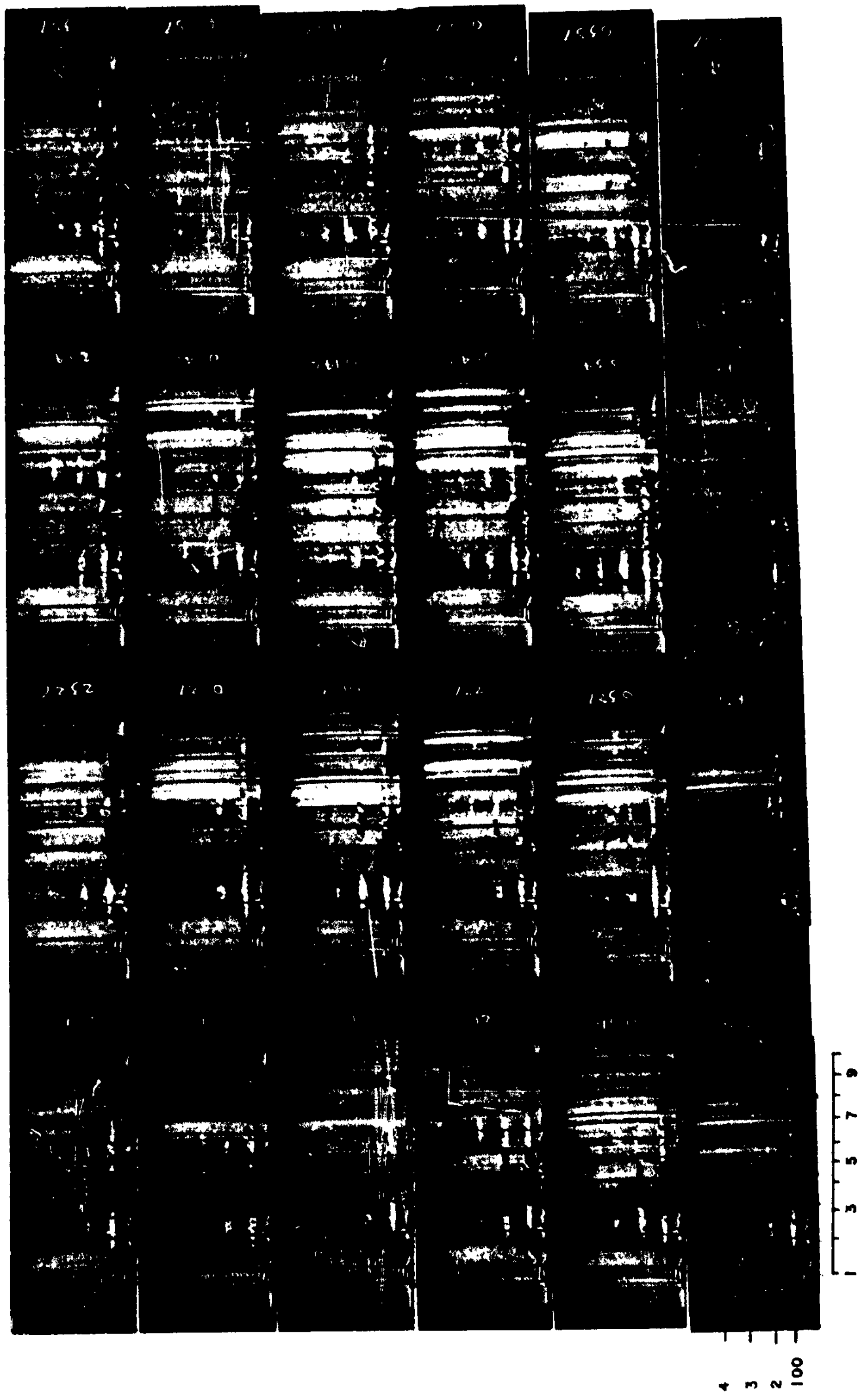
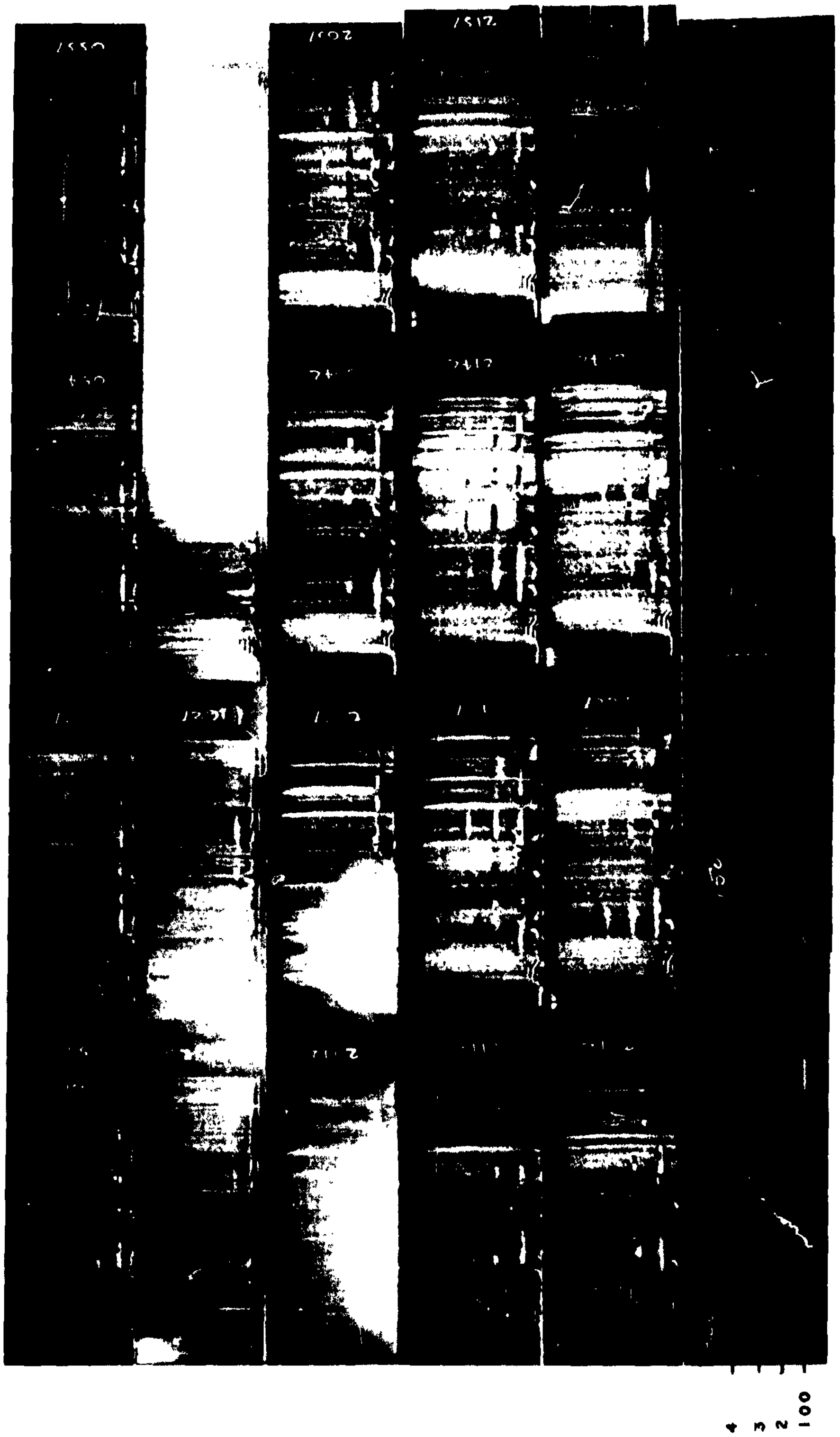
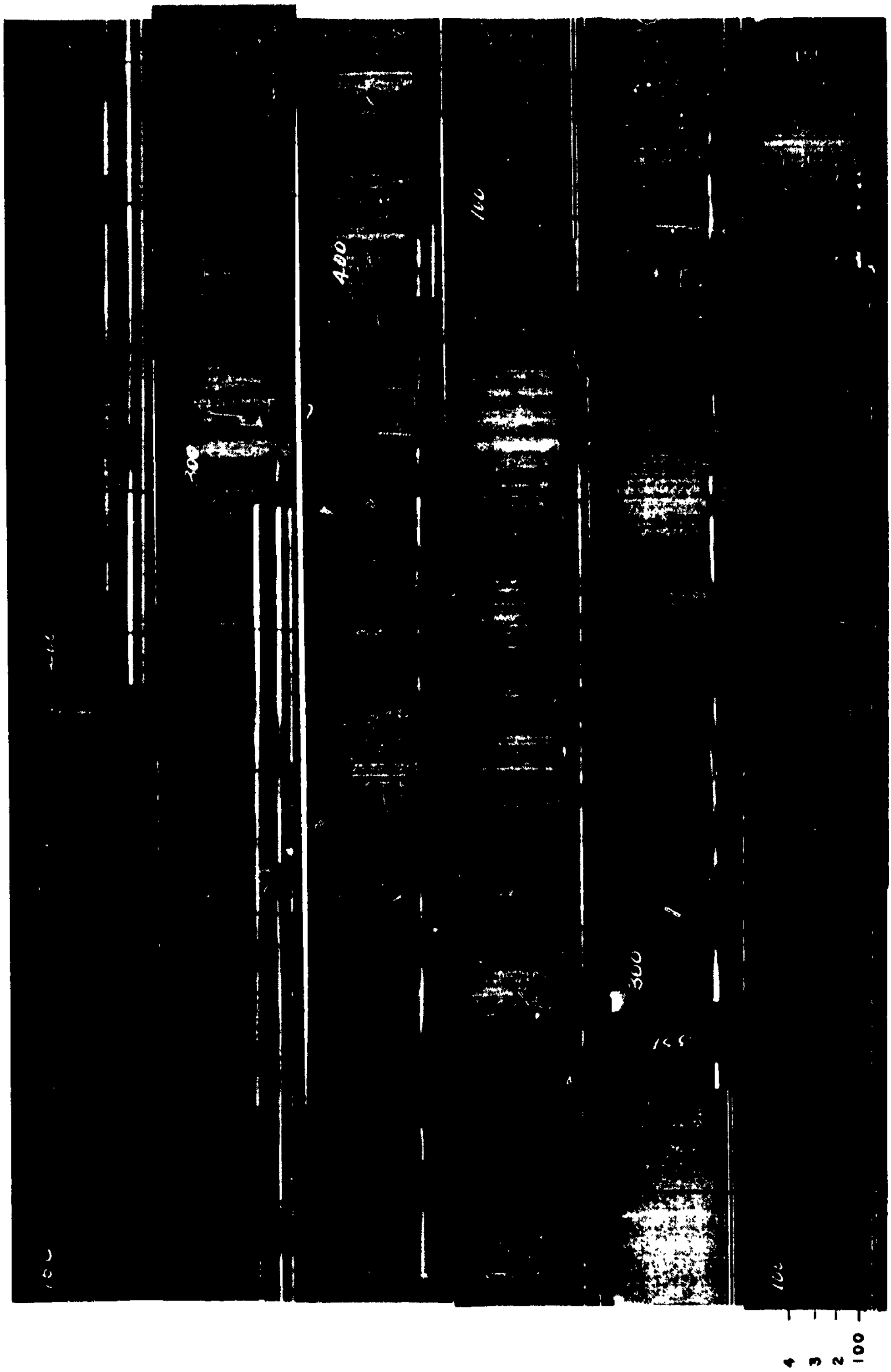
30 MAY 1712 - 2257 C = 0.1



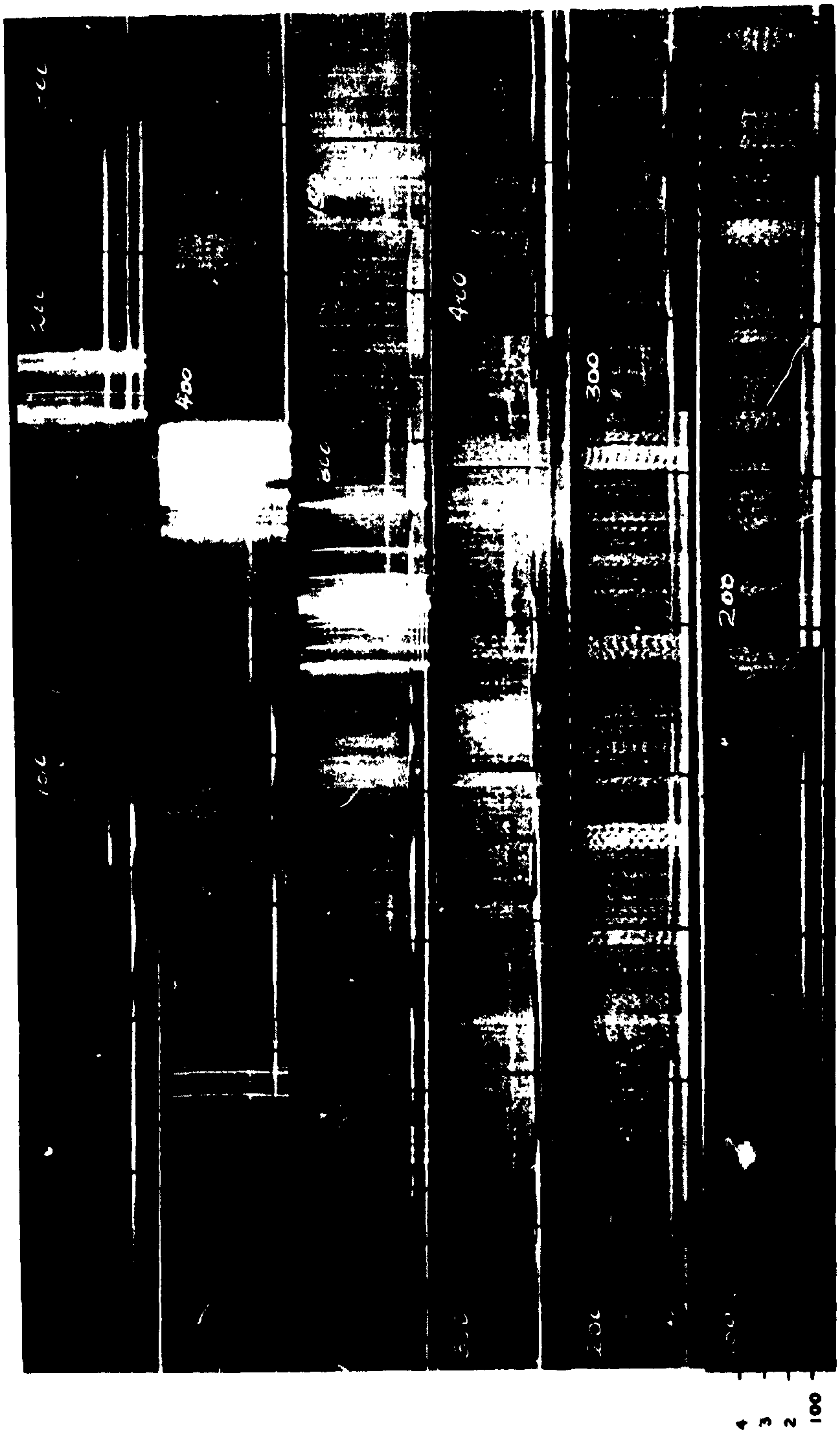
30 MAY 2312 - 2357 C=0.1
31 MAY 0012 - 0457 C=1.1



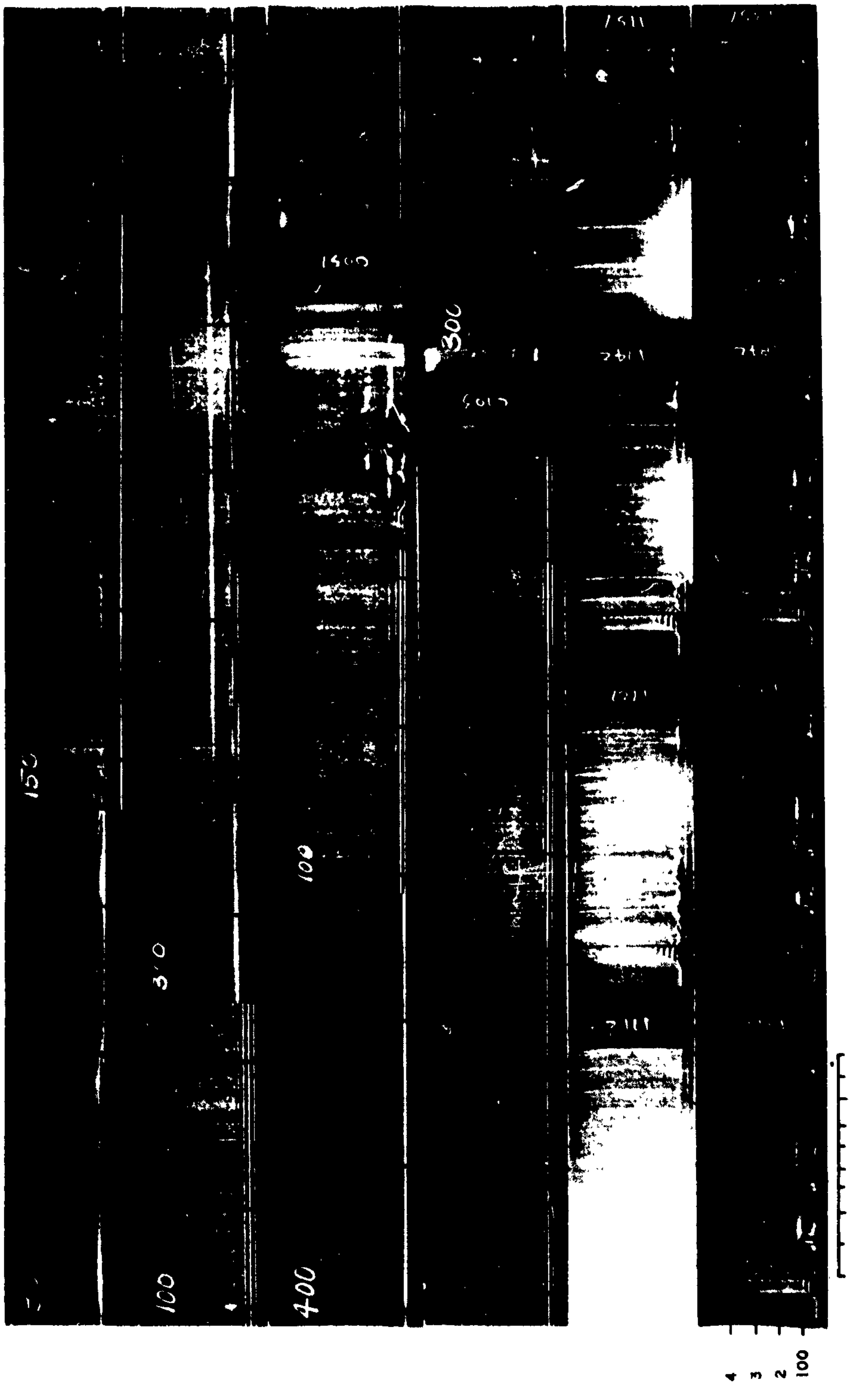
31 MAY 0512 - 0557 C = 1.1
31 MAY 2012 - 2320 C = 1.1



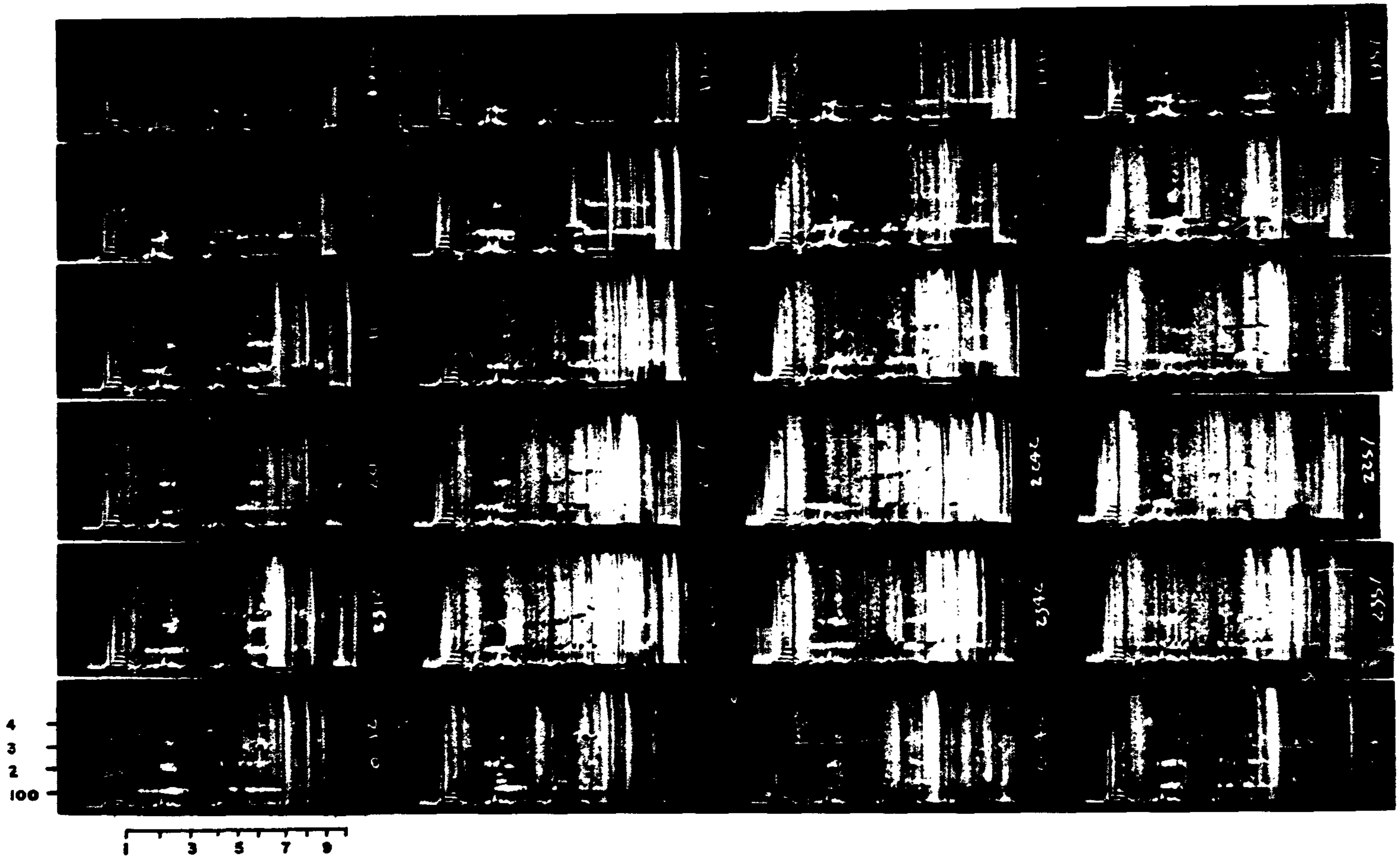
31 MAY 2321 - 2351 C = 1.1



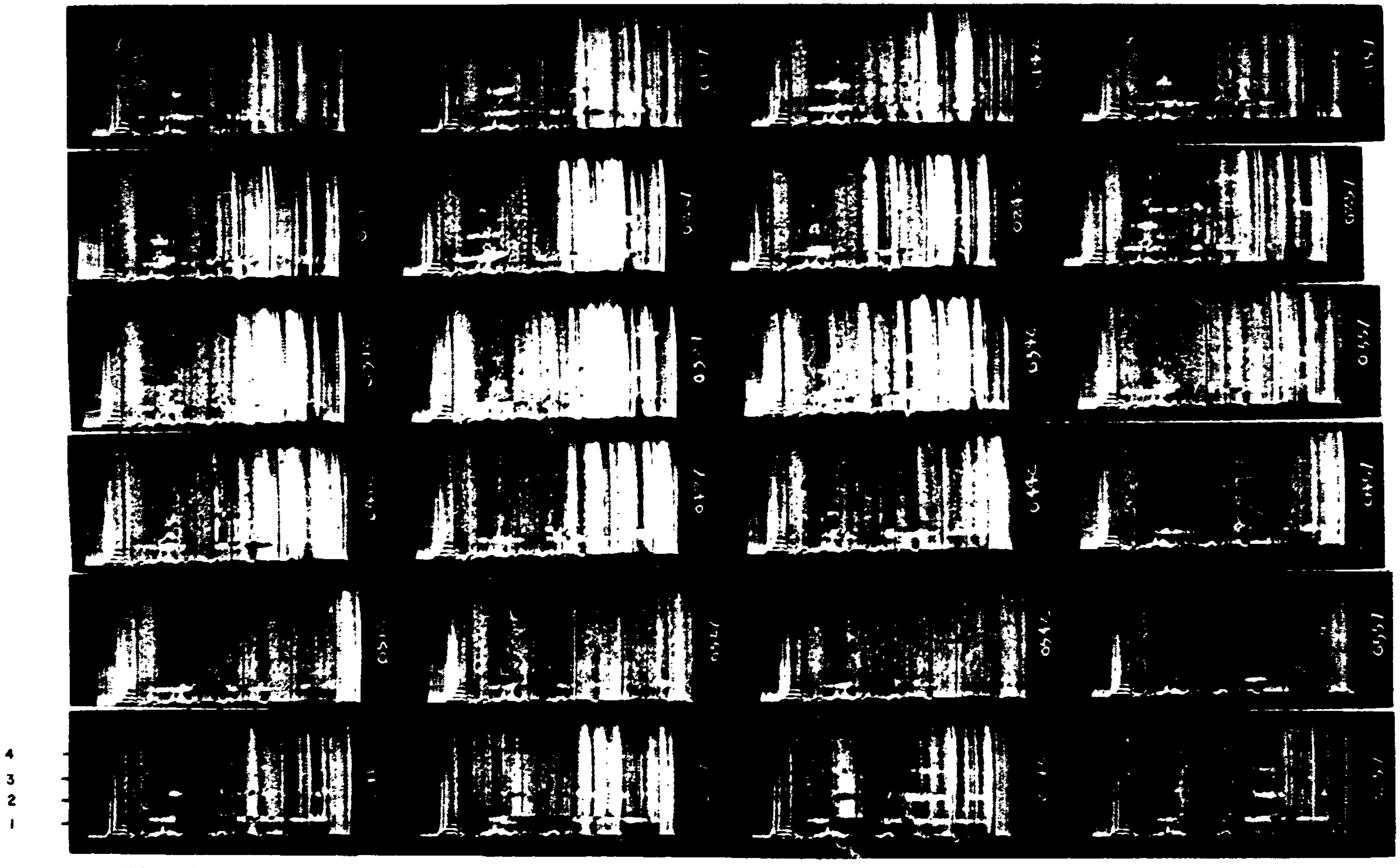
31 MAY 2352 - 2400 C = 1.1
1 JUNE 0001 - 0025 C = 0.7



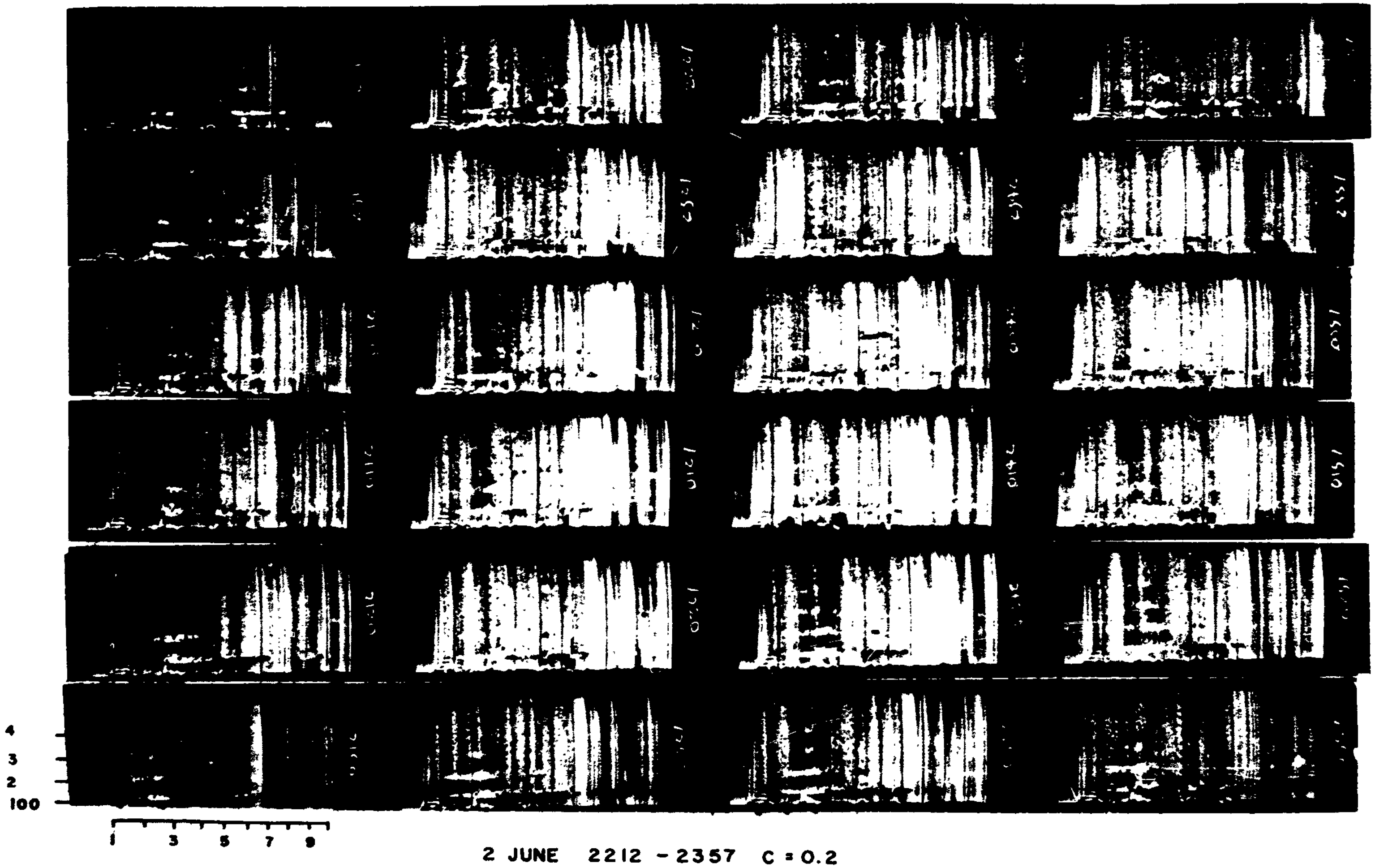
1 JUNE 0025 - 0105 C=0.7
1 JUNE 1712 - 1857 C=0.7



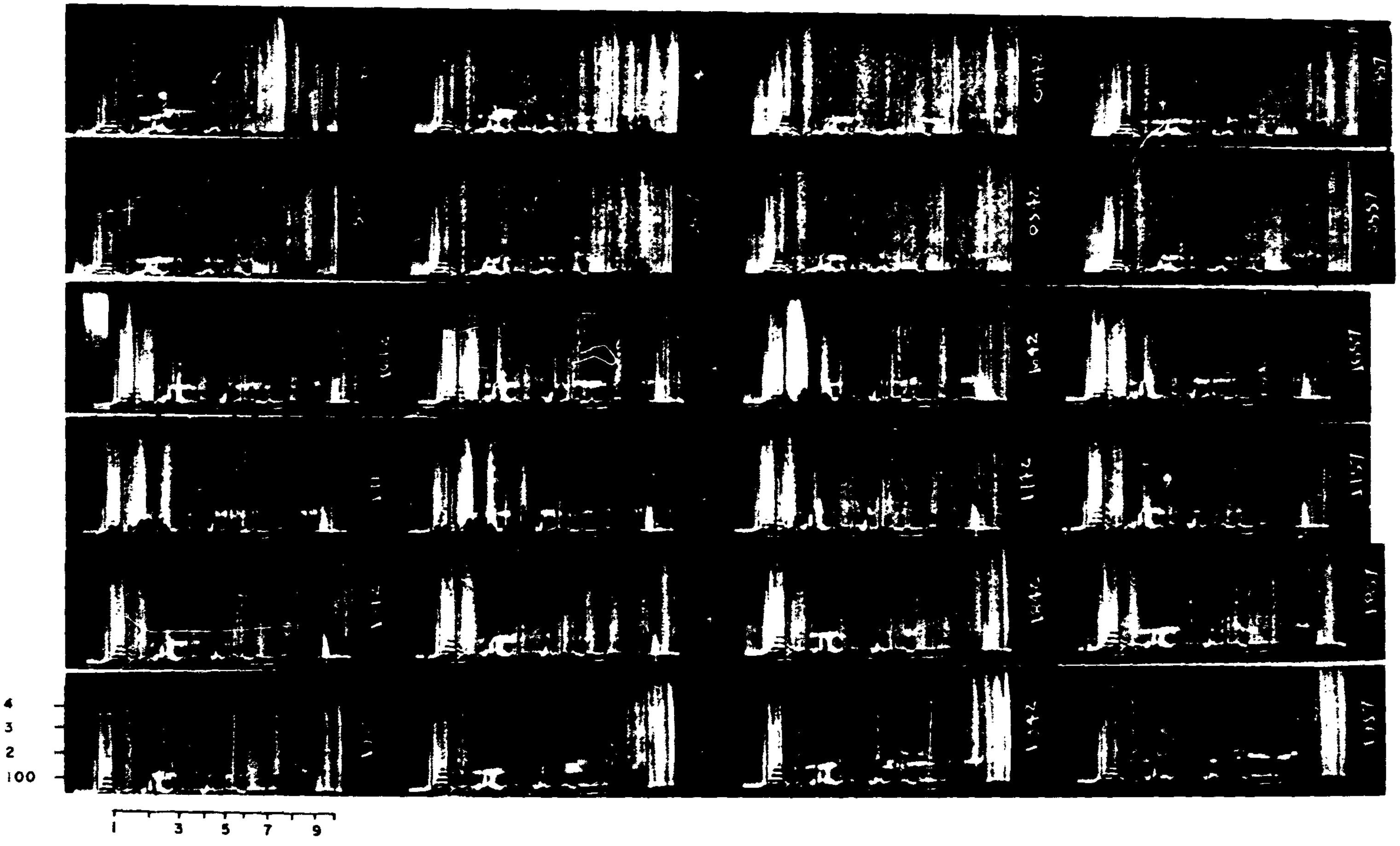
1 JUNE 1912 - 2357 C = 0.7
2 JUNE 0012 - 0057 C = 0.2



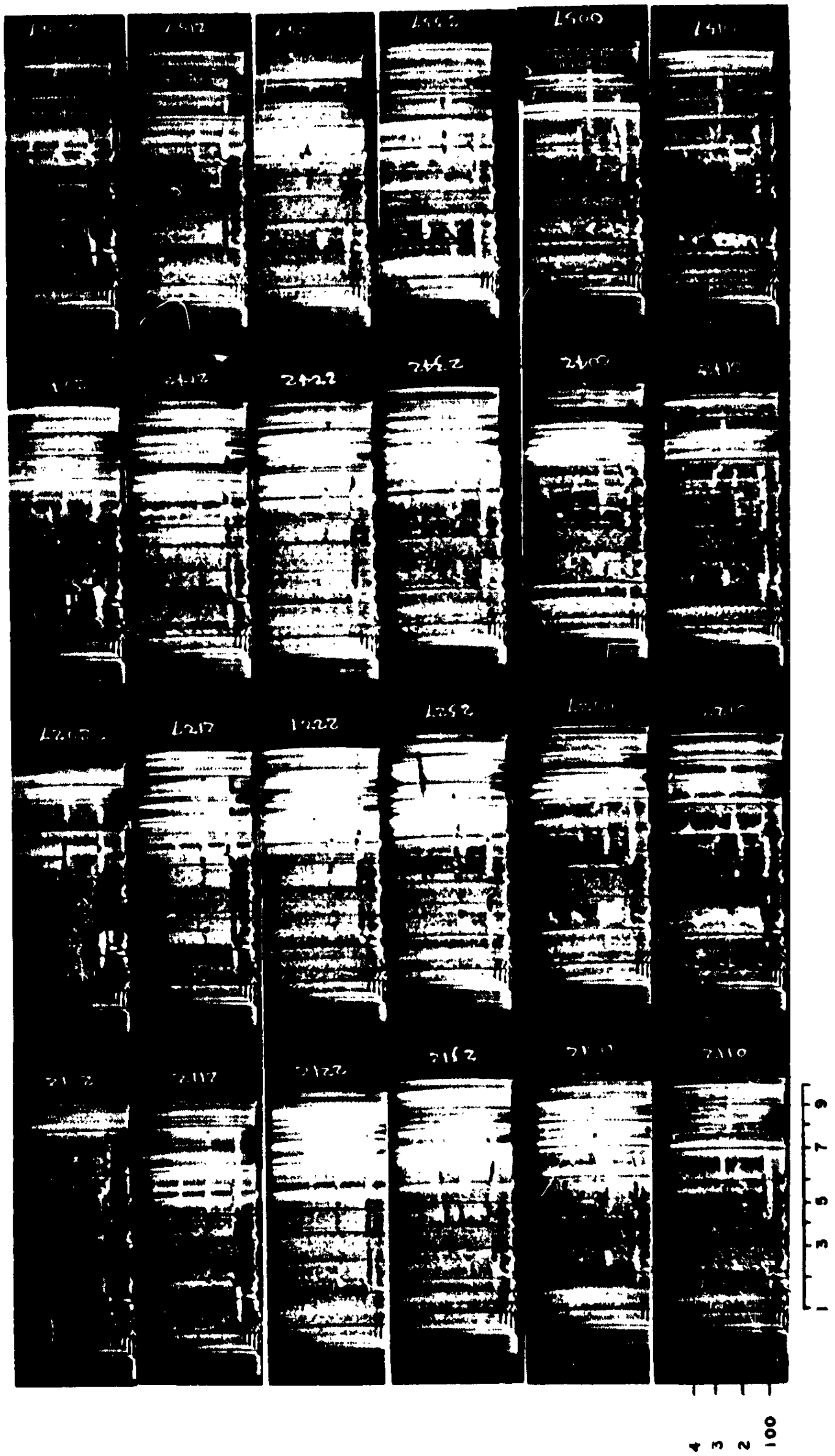
2 JUNE 0112 - 0557 C=0.2
2 JUNE 2112 - 2157 C=0.2



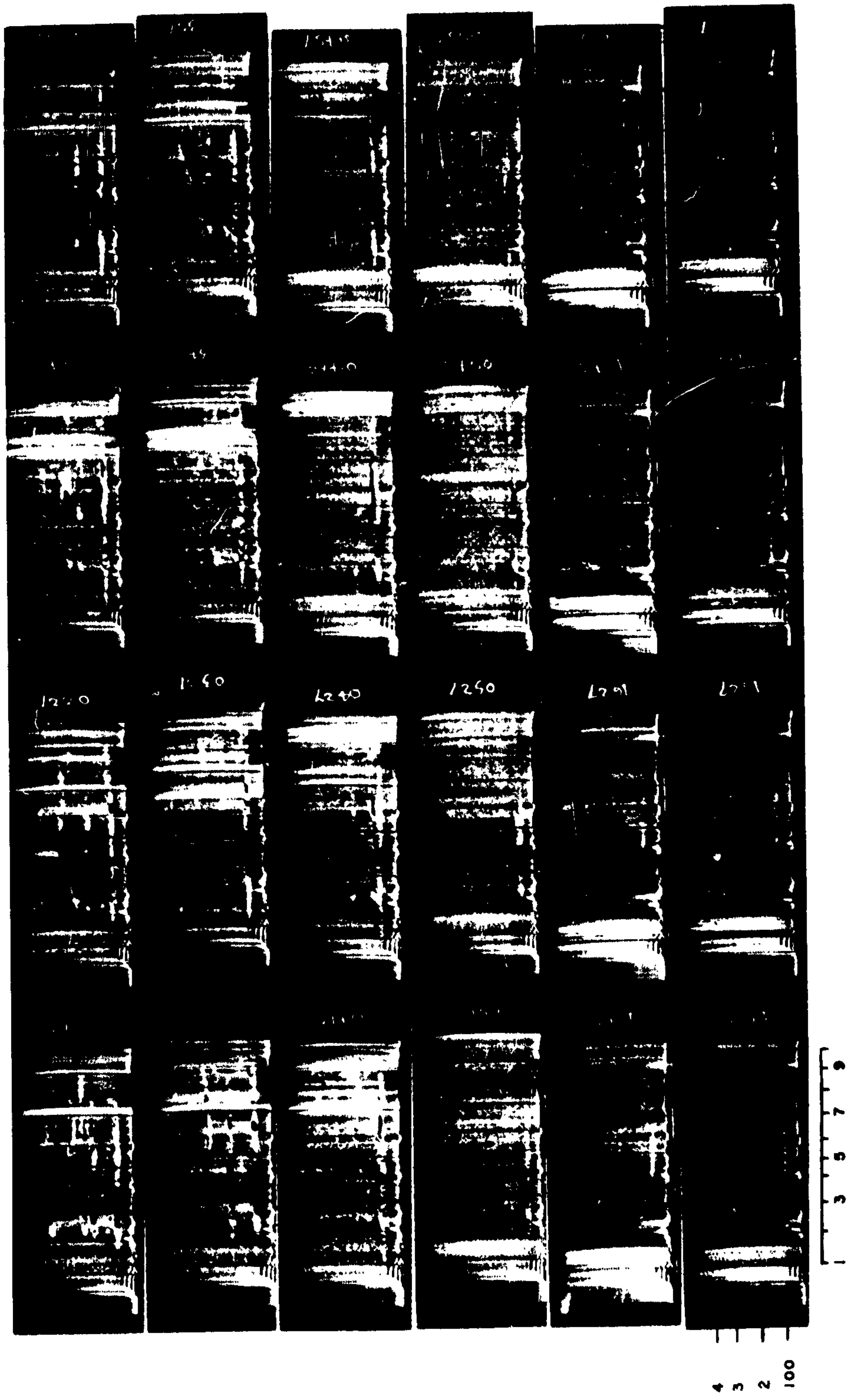
2 JUNE 2212 - 2357 C = 0.2
3 JUNE 0012 - 0357 C = 0.3



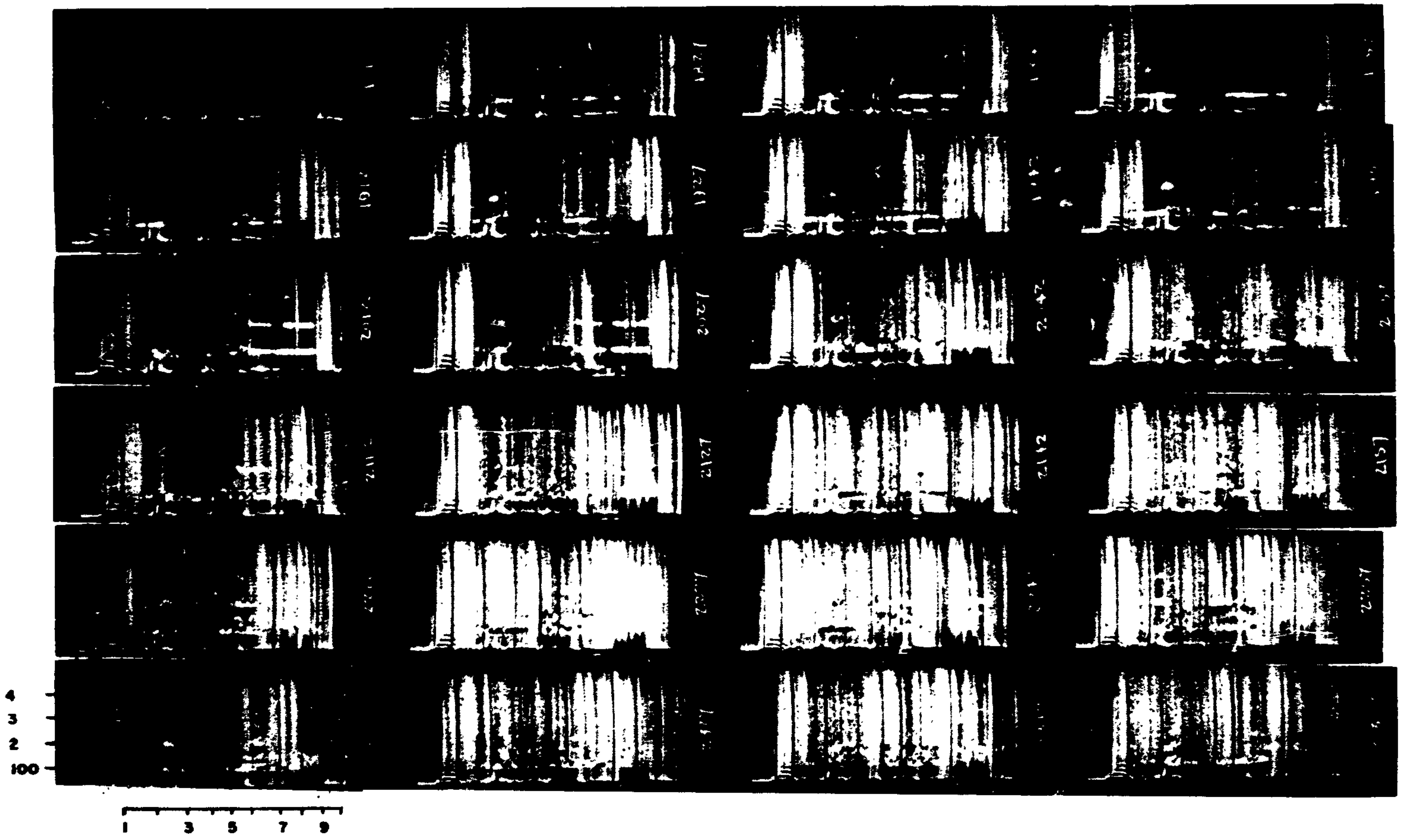
3 JUNE 0412 - 0557 C=0.3
3 JUNE 1612 - 1957 C=0.3



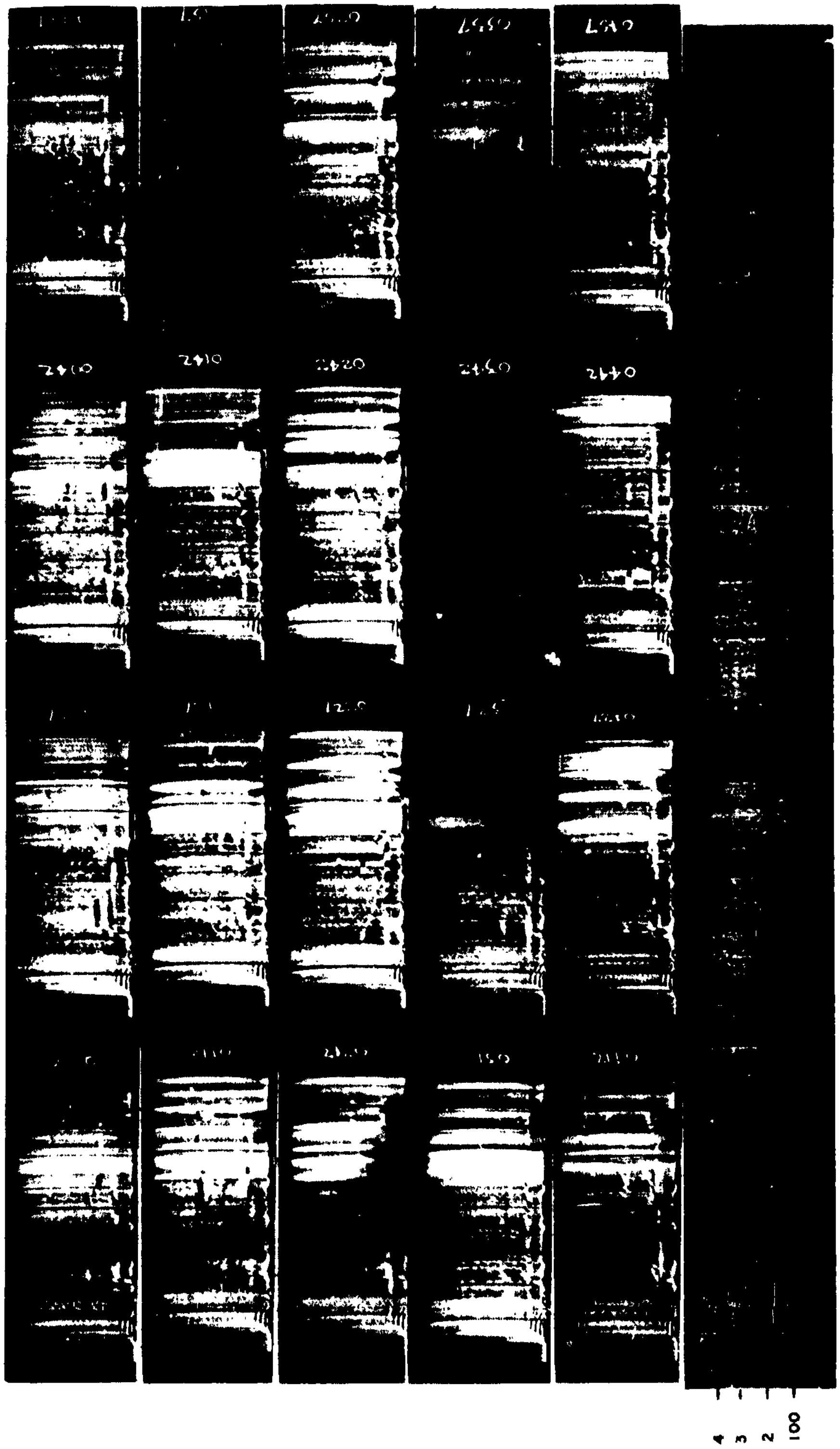
3 JUNE 2012 - 2357 C=0.3
4 JUNE 0012 - 0157 C= 1.0



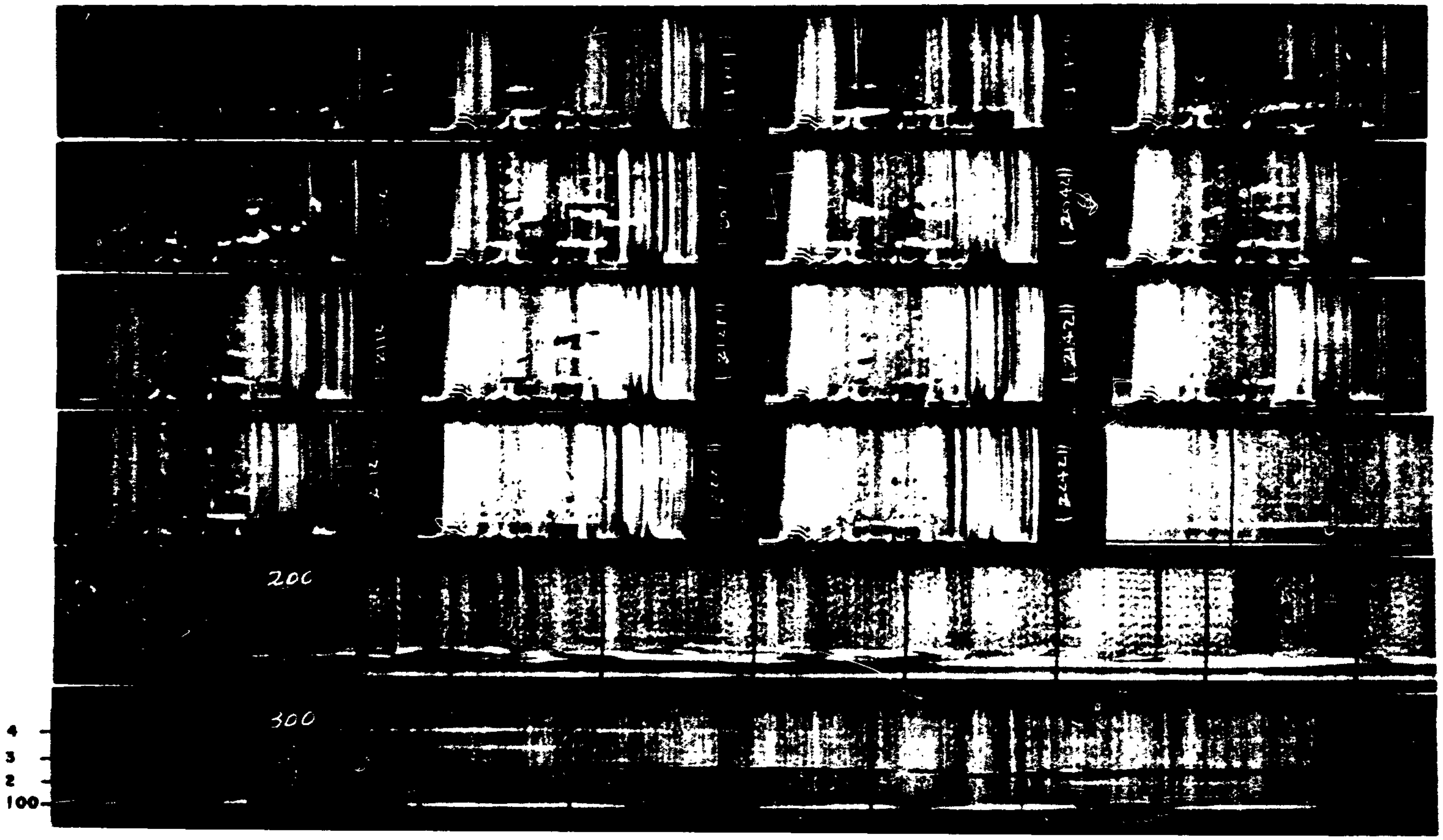
4 JUNE 0212 - 0557 C=1.0
4 JUNE 1612 - 1757 C=1.0



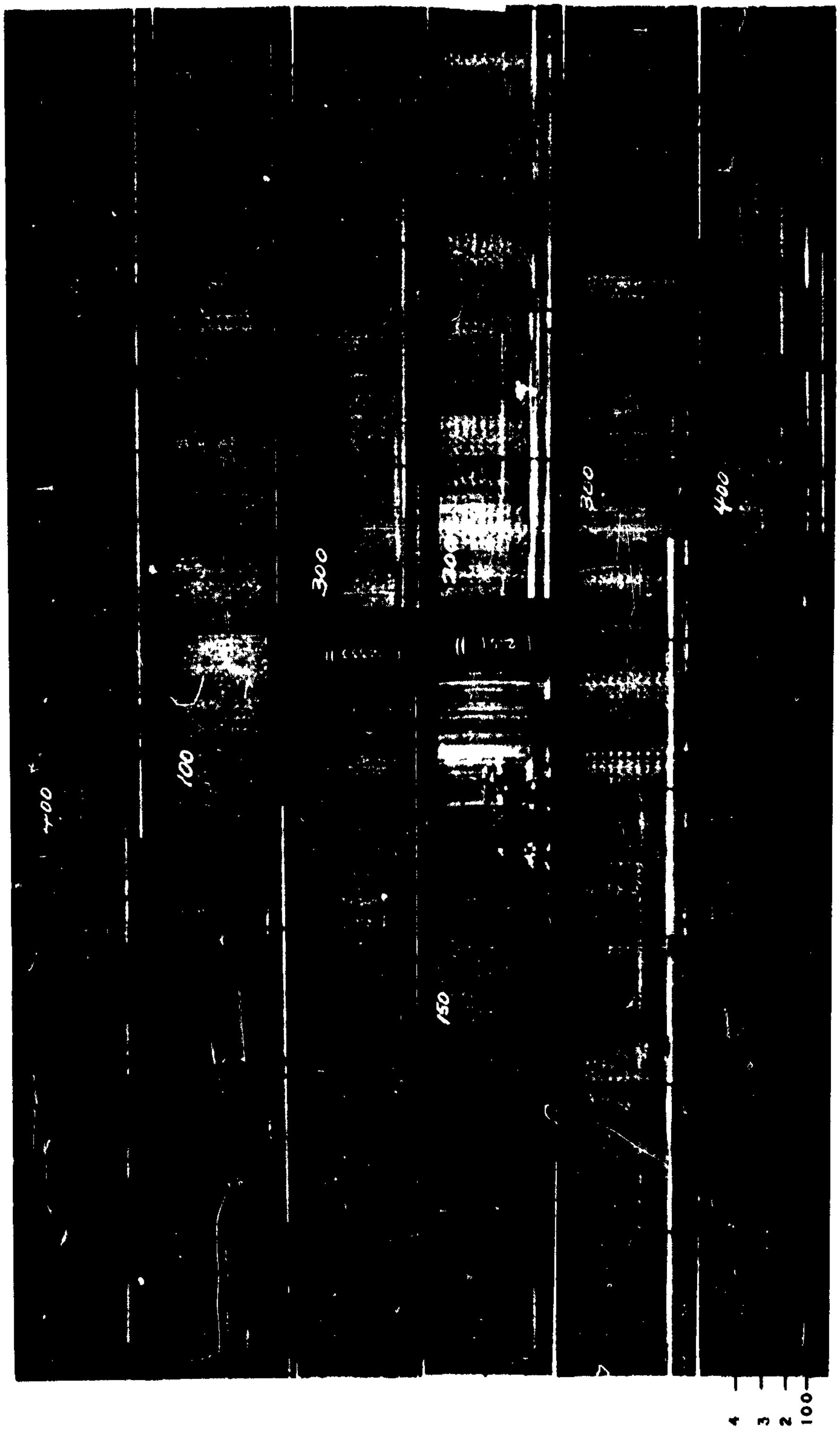
4 JUNE 1812 - 2357 C = 1.0



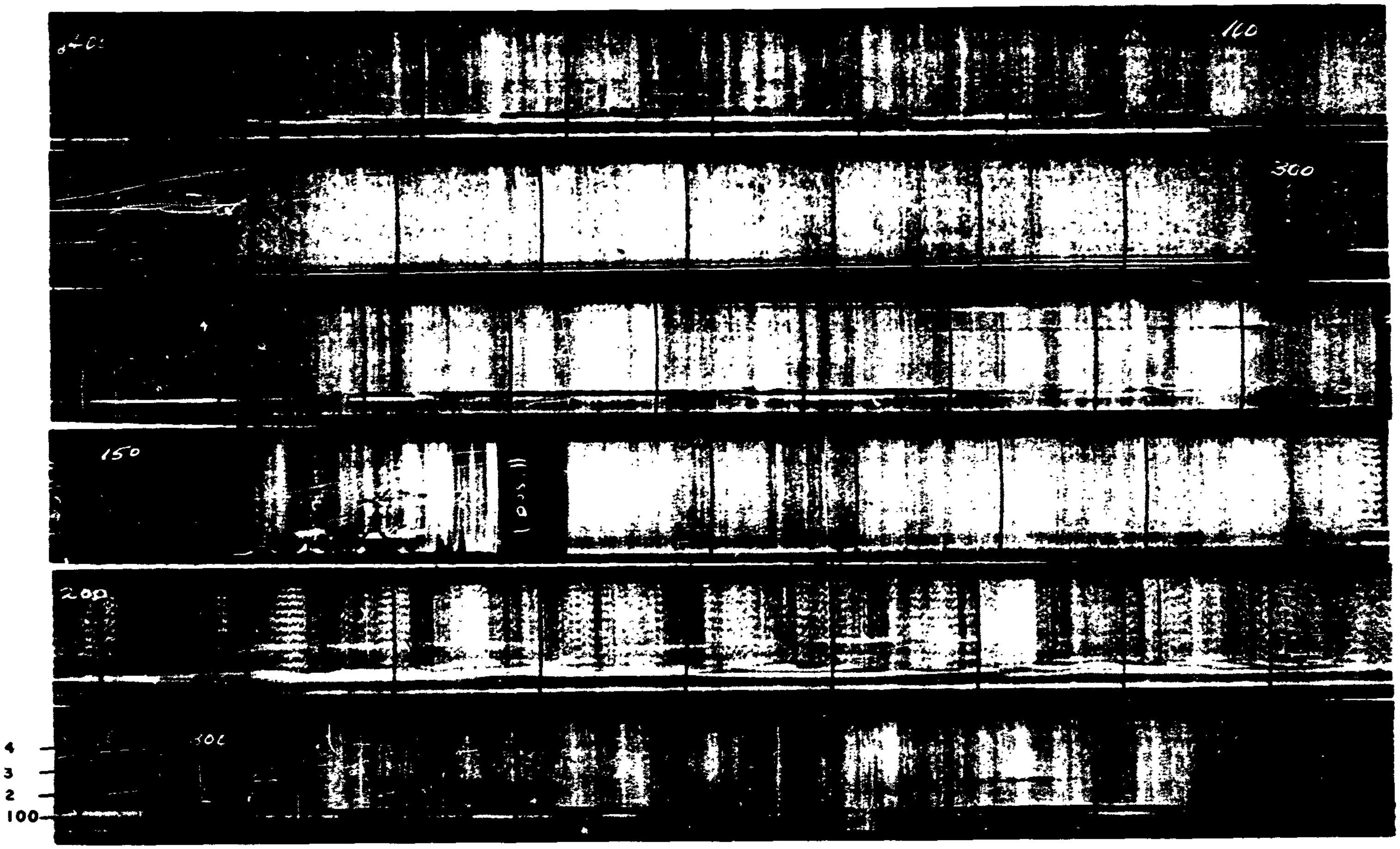
5 JUNE 0012 – 0457 C=0.8



5 JUNE 1912-2320 C=0.8



5 JUNE 2321-2359 C=0.8
6 JUNE 0000-0013 C=0.7


160
300
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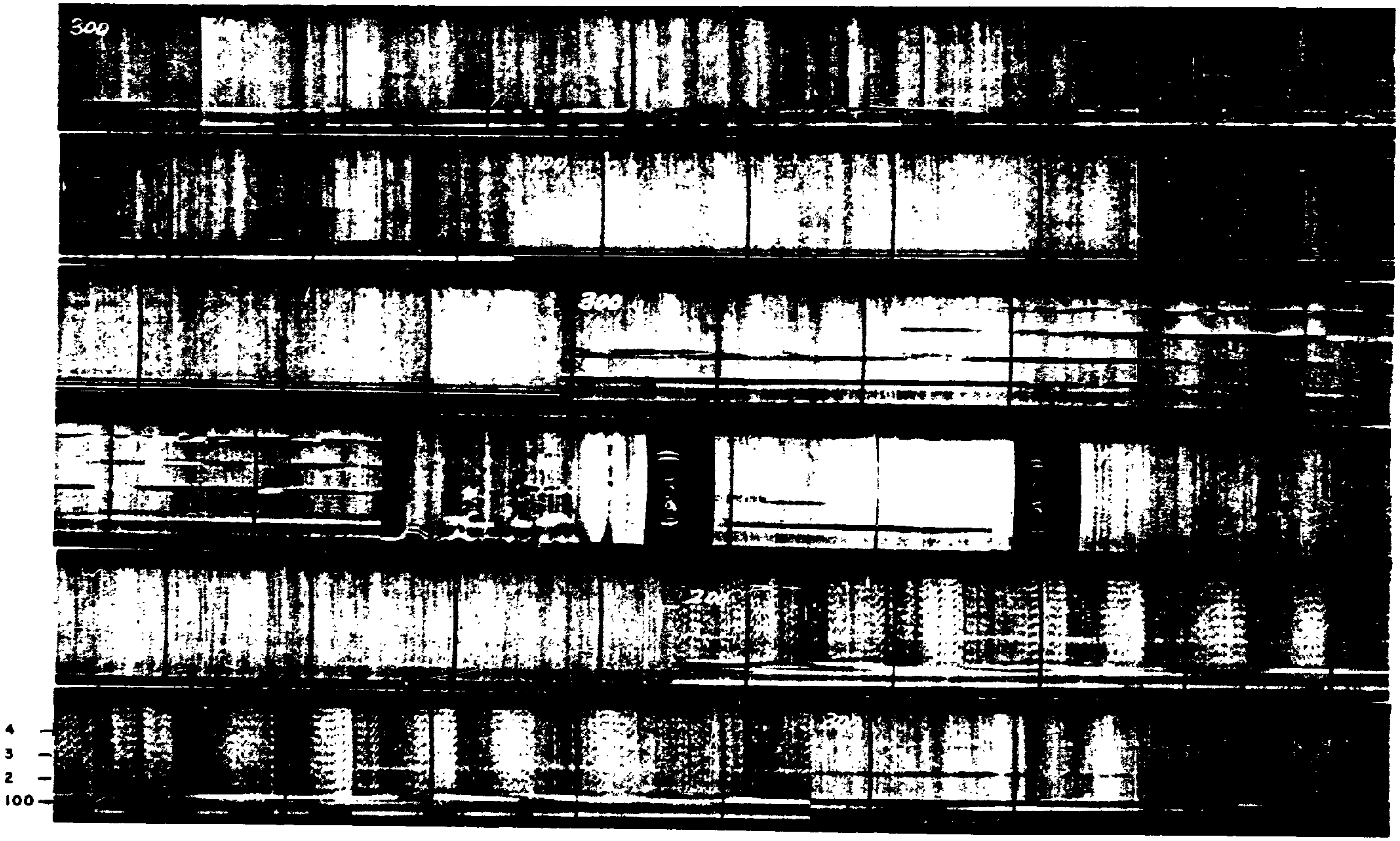
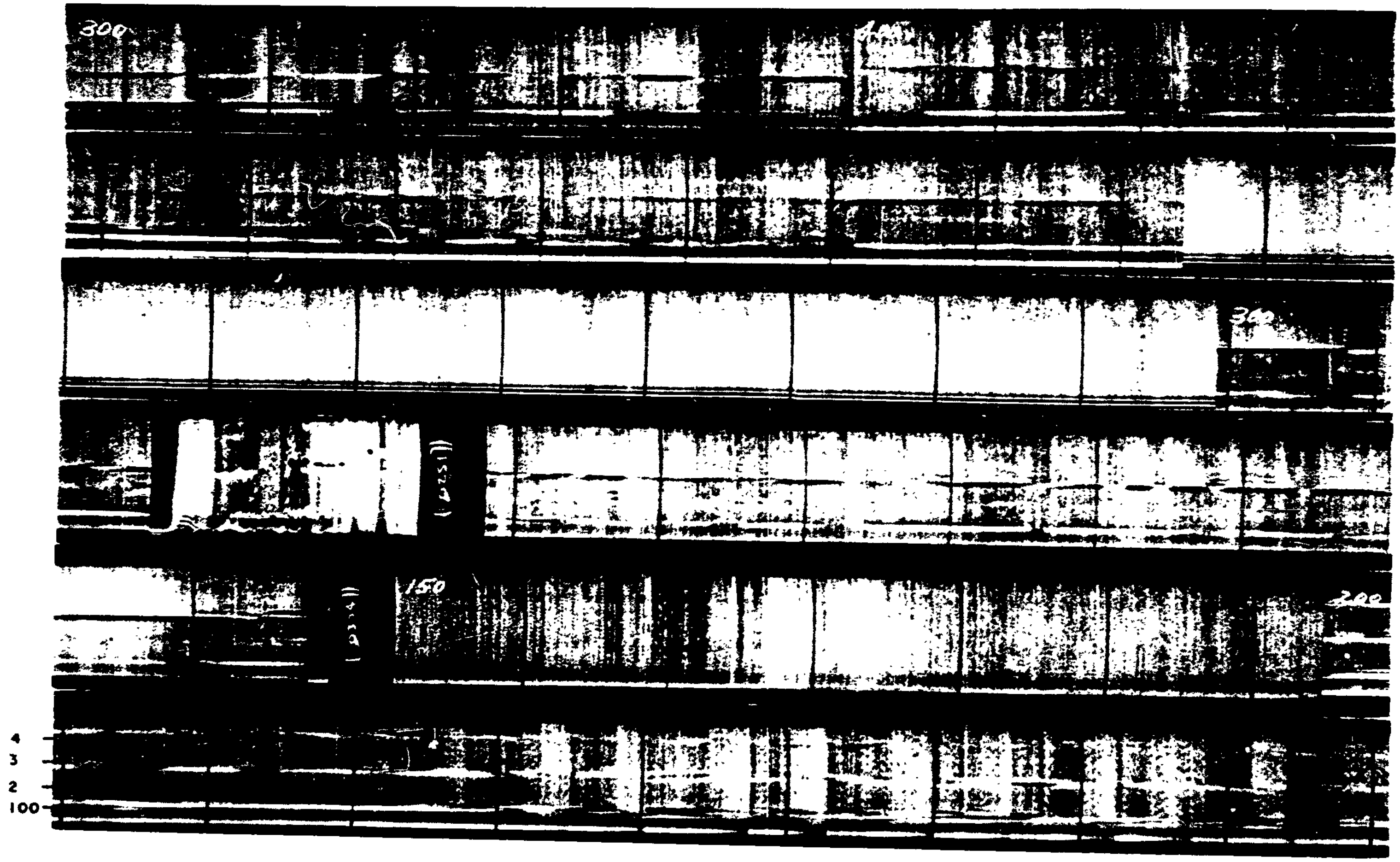
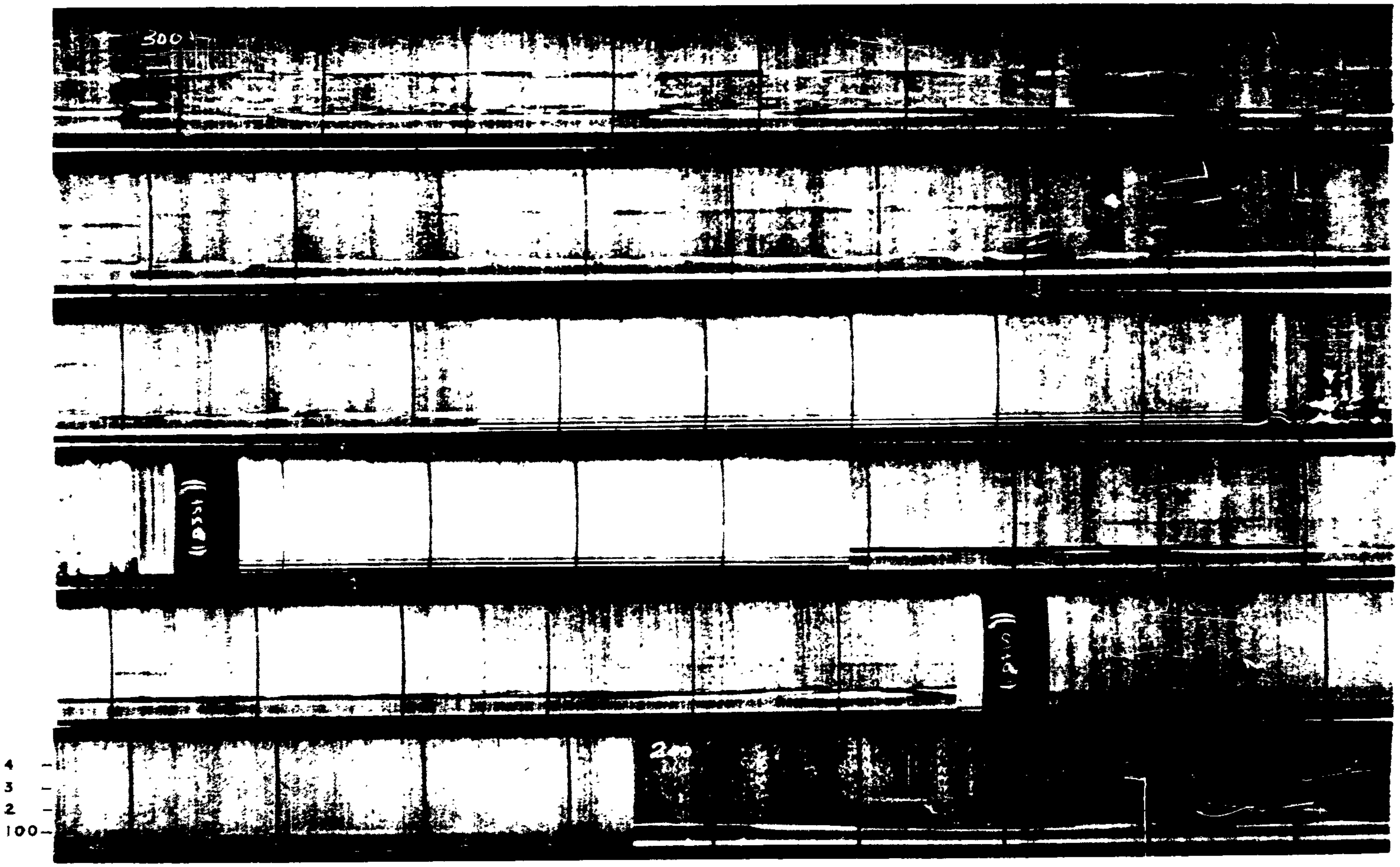
6 JUNE 0014-0116 C=0.7



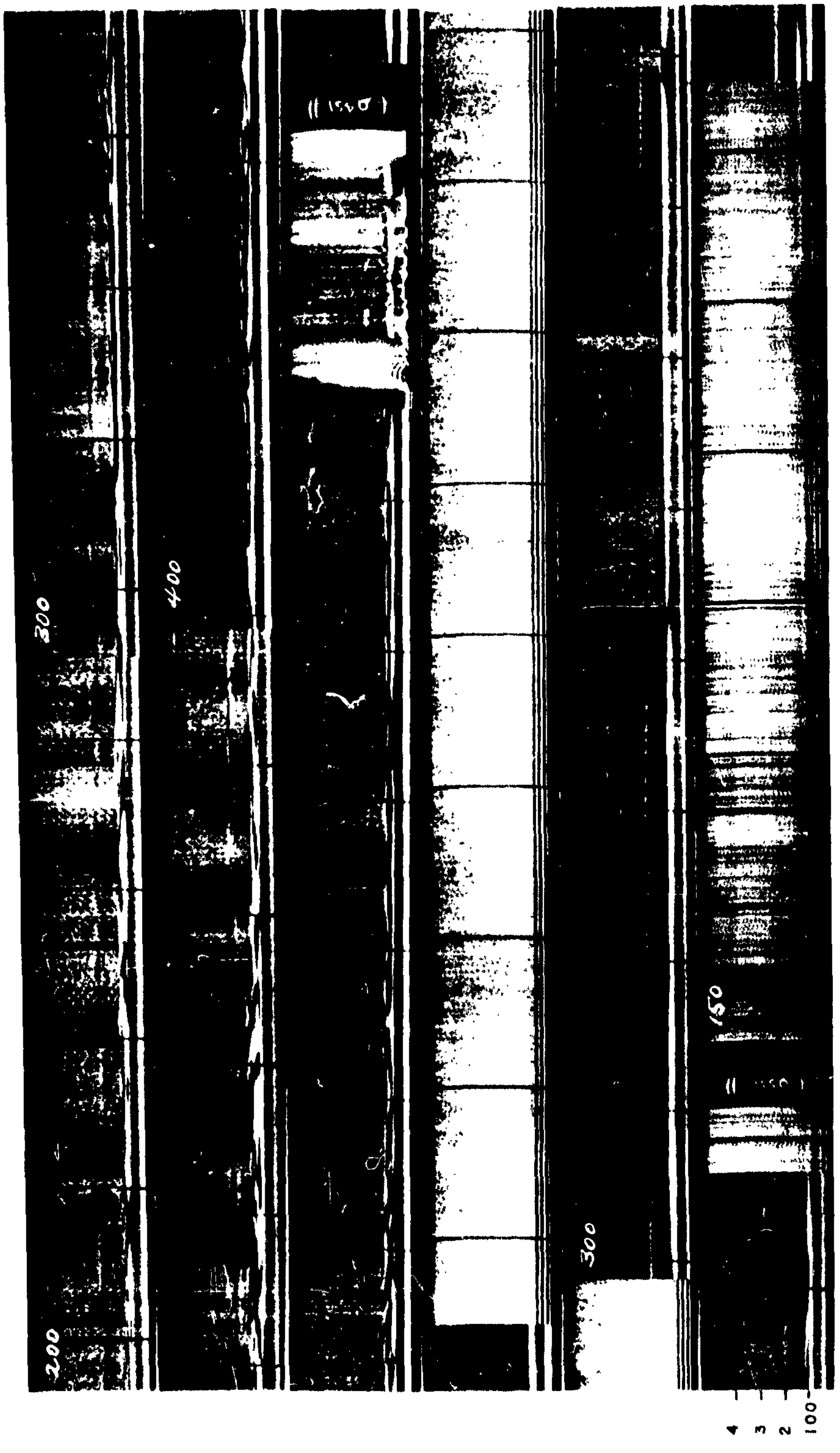
6 JUNE 0117-0219 C=0.7



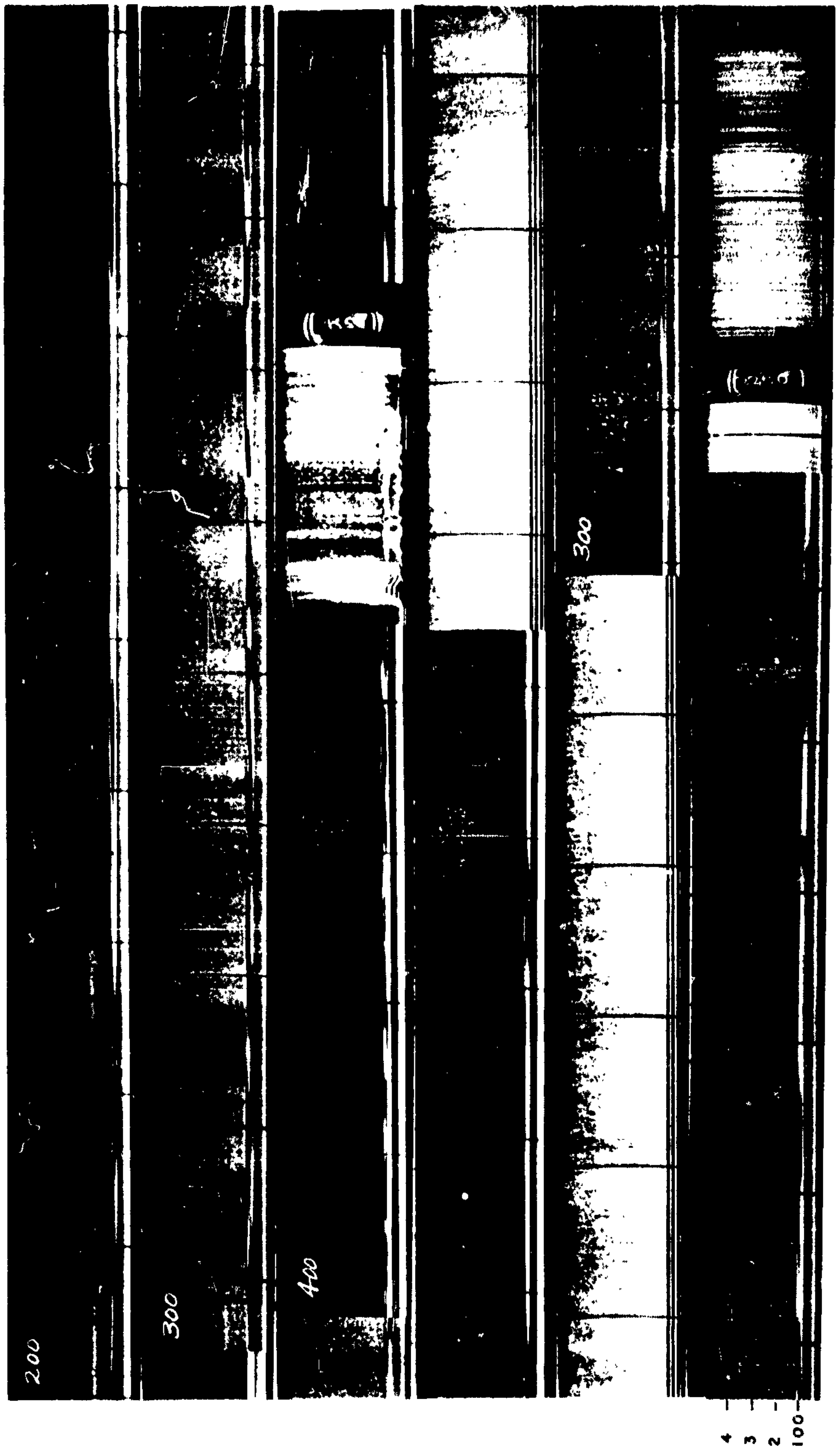
6 JUNE 0220-0320 C=0.7



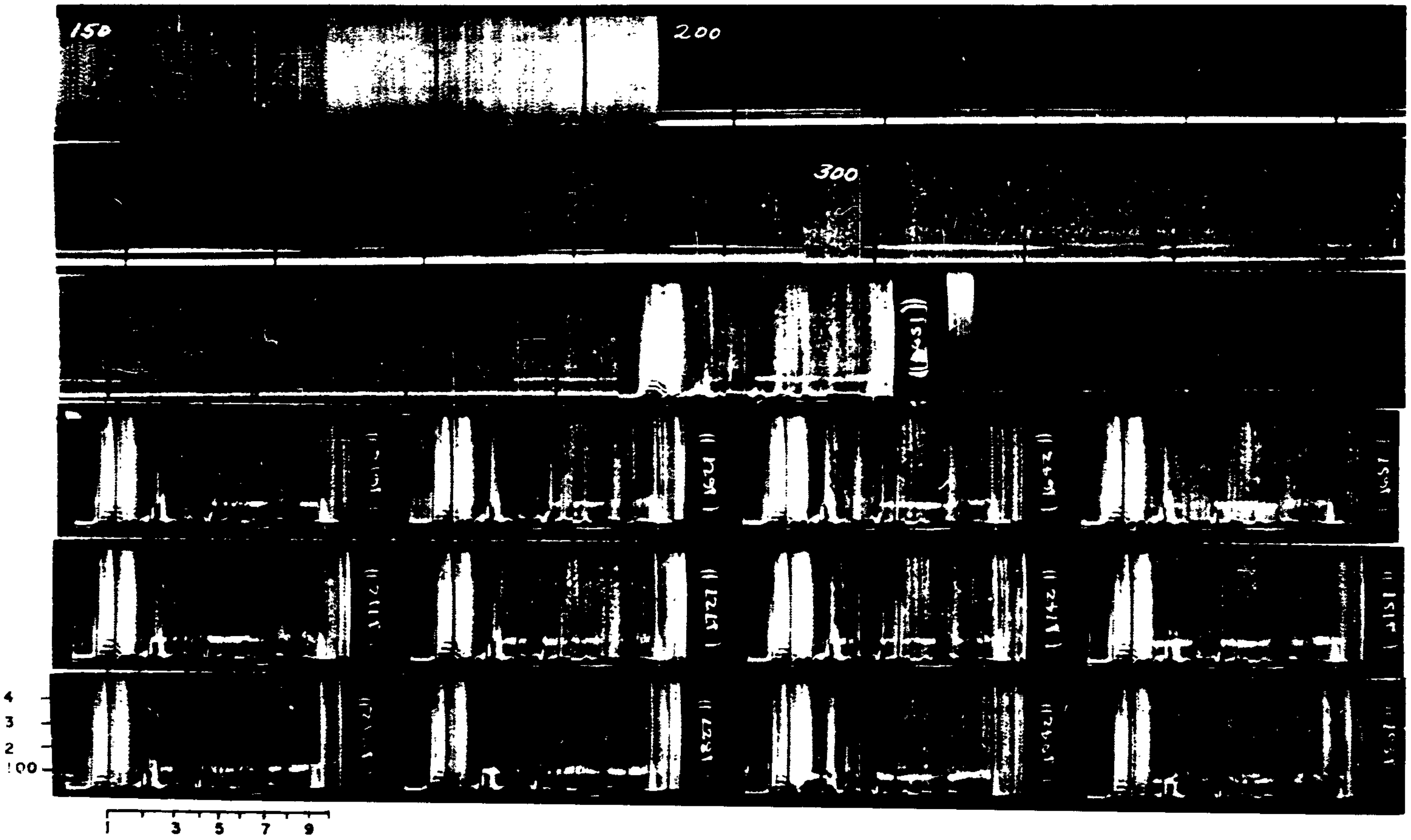
6 JUNE 0321-0421 C=0.7



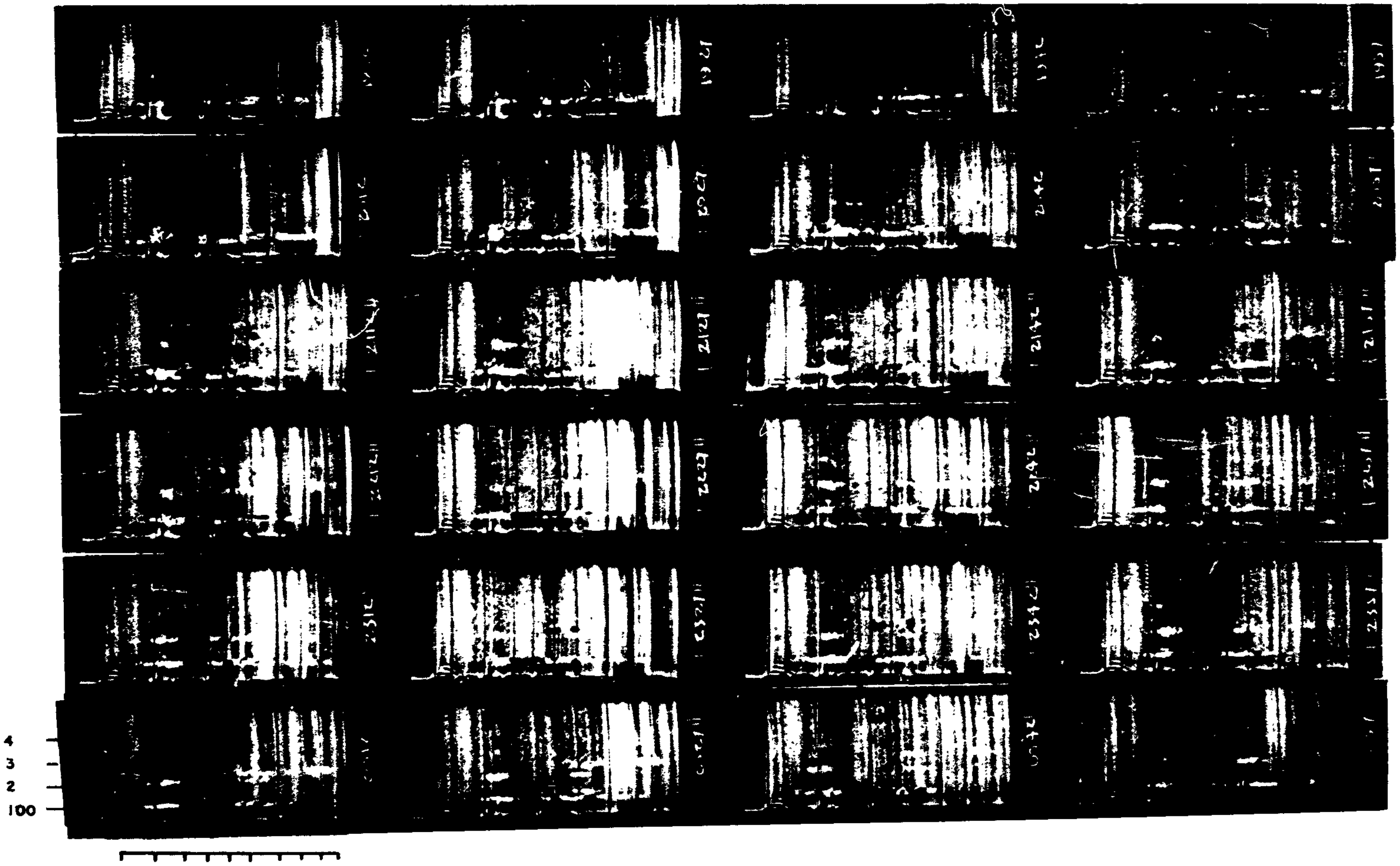
6 JUNE 0422-0523 C=0.7



6 JUNE 0524-0624 C=0.7



6 JUNE 0625 - 0651 C=0.7
6 JUNE 1512 - 1857 C=0.7


4
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100
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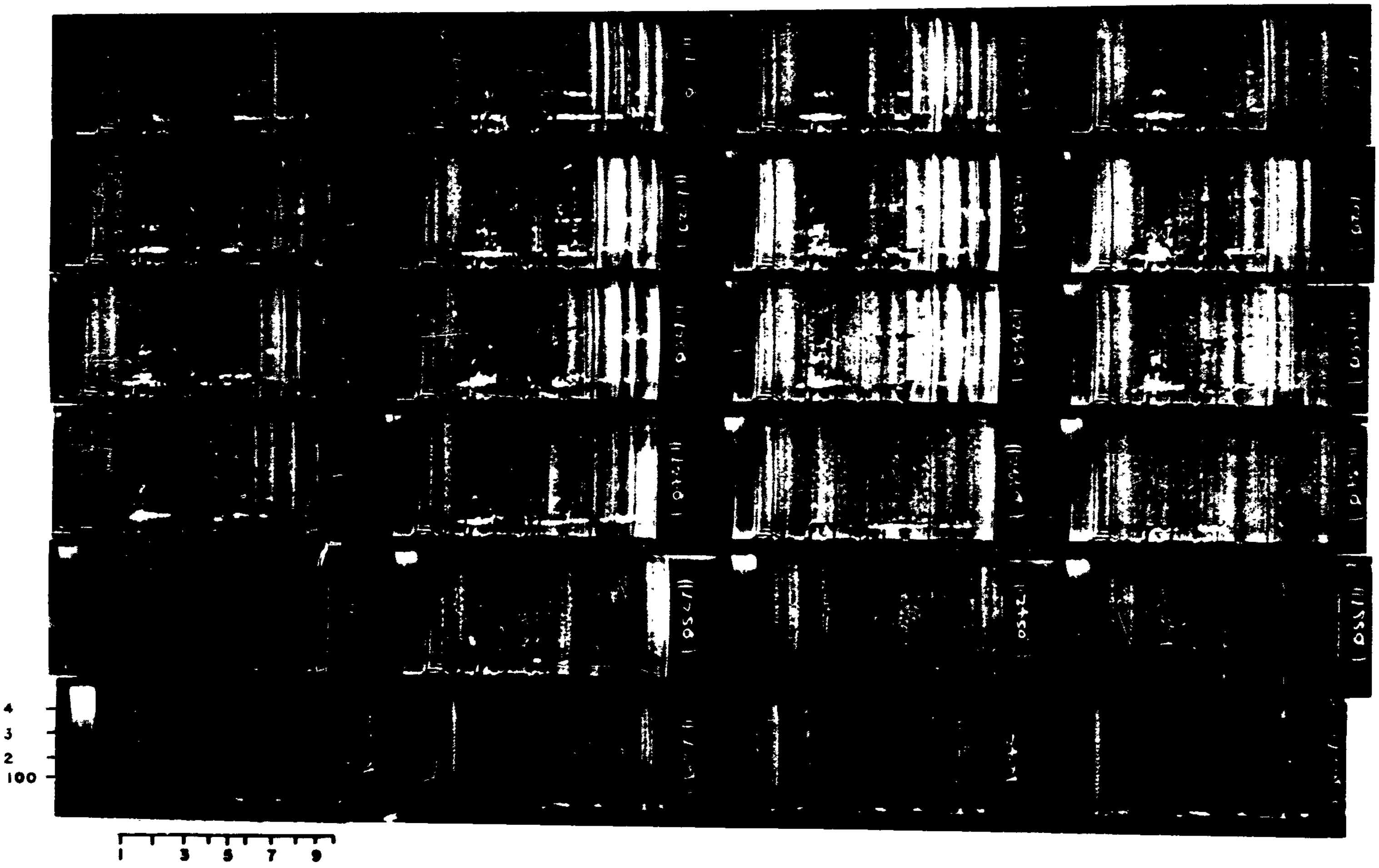
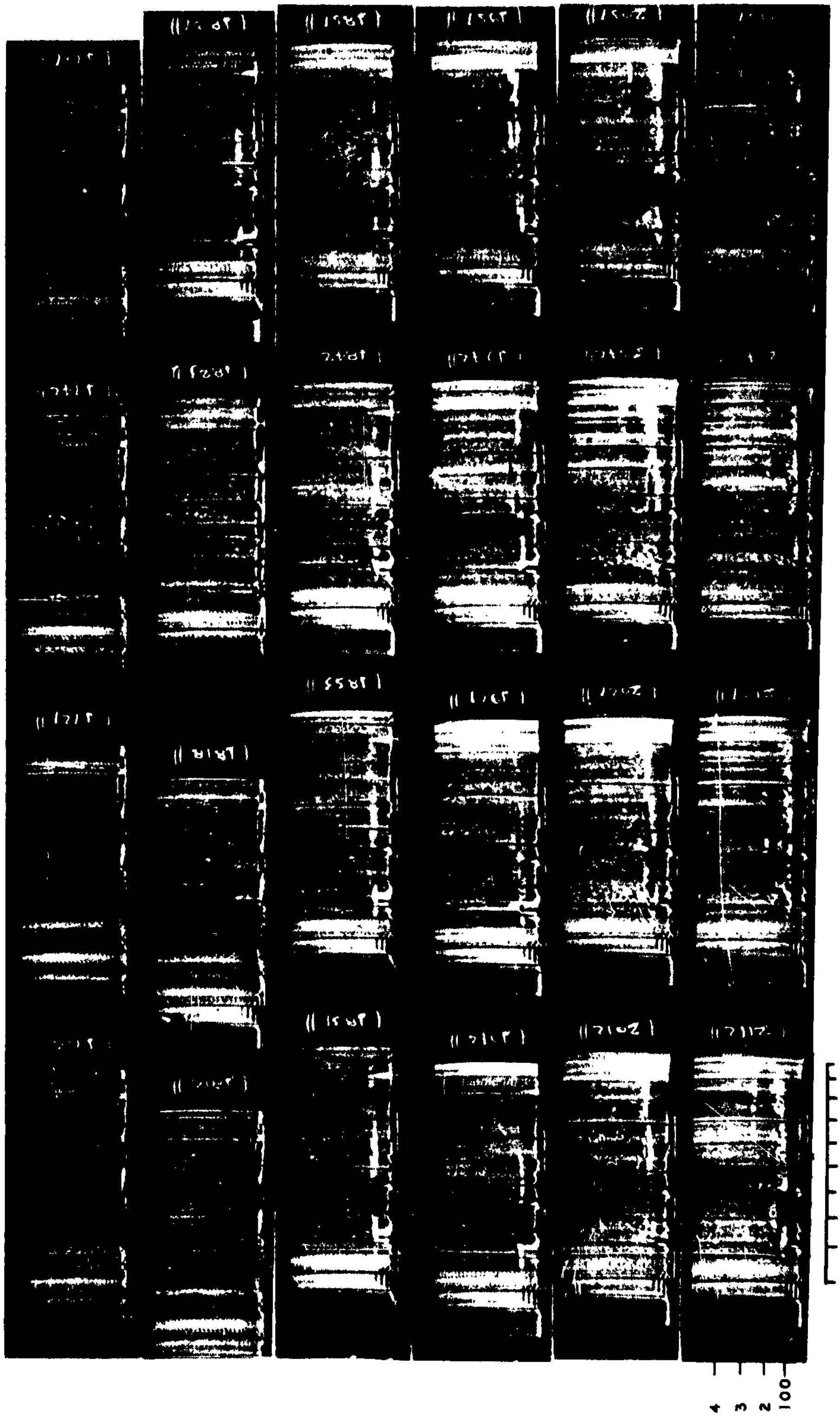
9

6 JUNE 1912–2357 C=0.7
7 JUNE 0012–0057 C=0.8



7 JUNE 0112-0557 C=0.8
7 JUNE 1612-1657 C=0.8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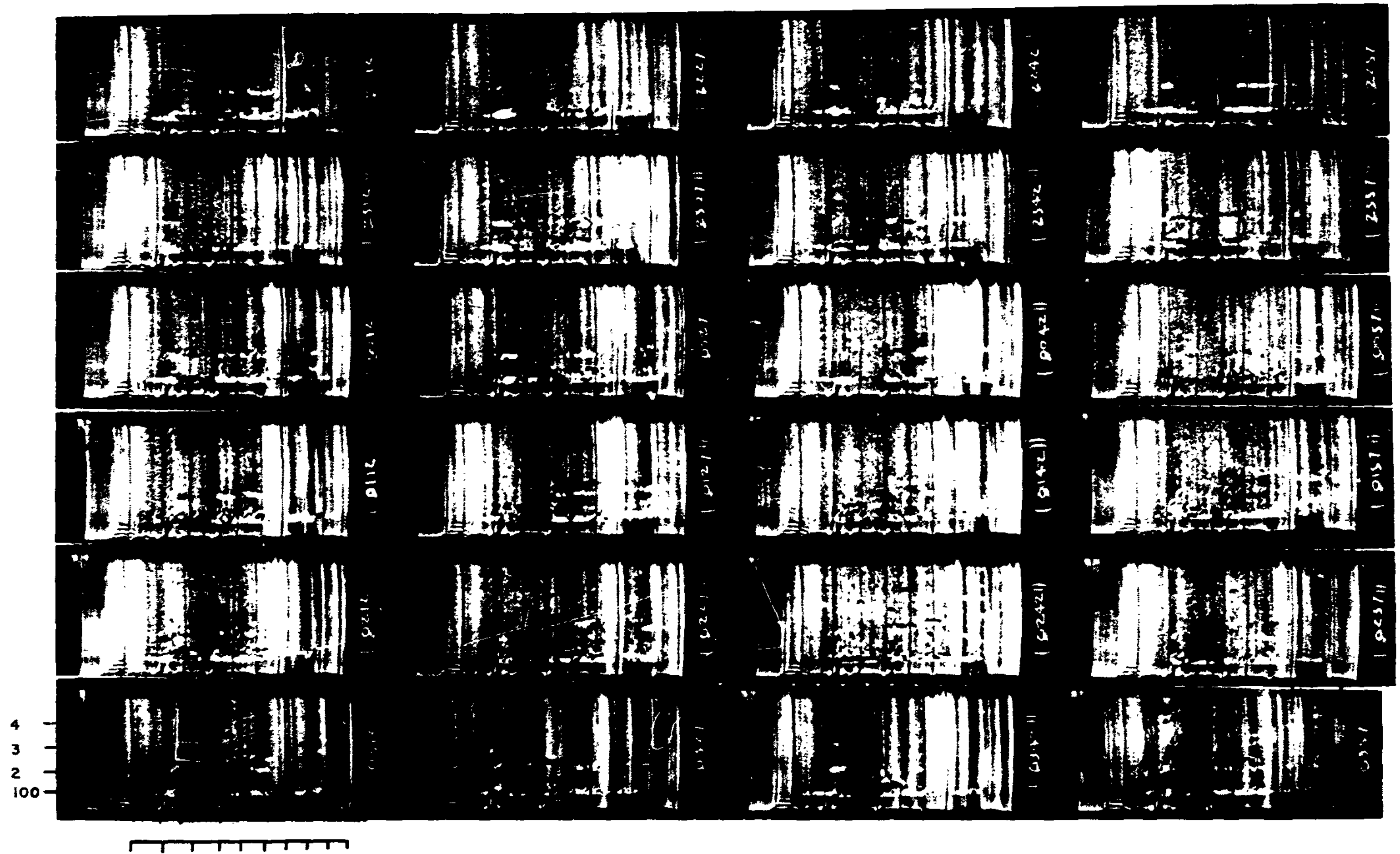
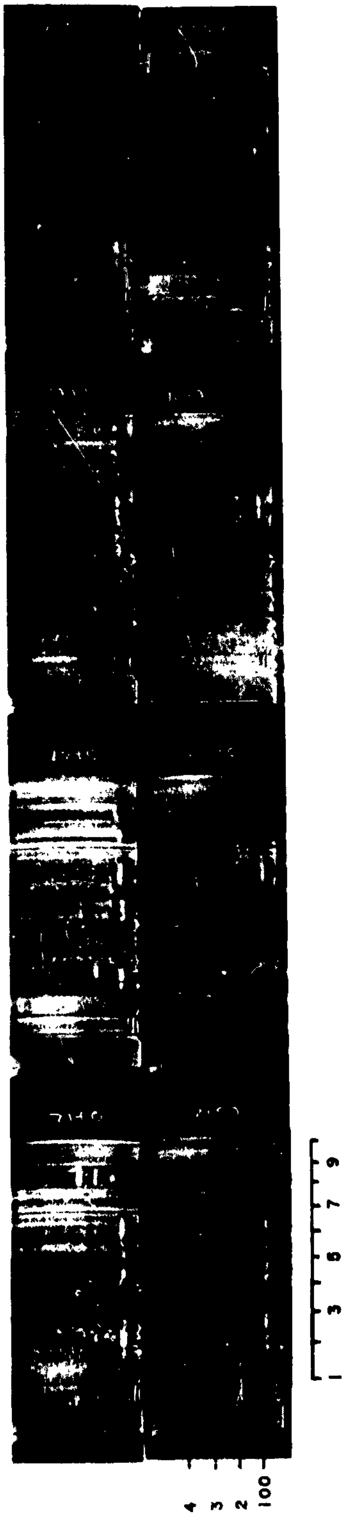
100

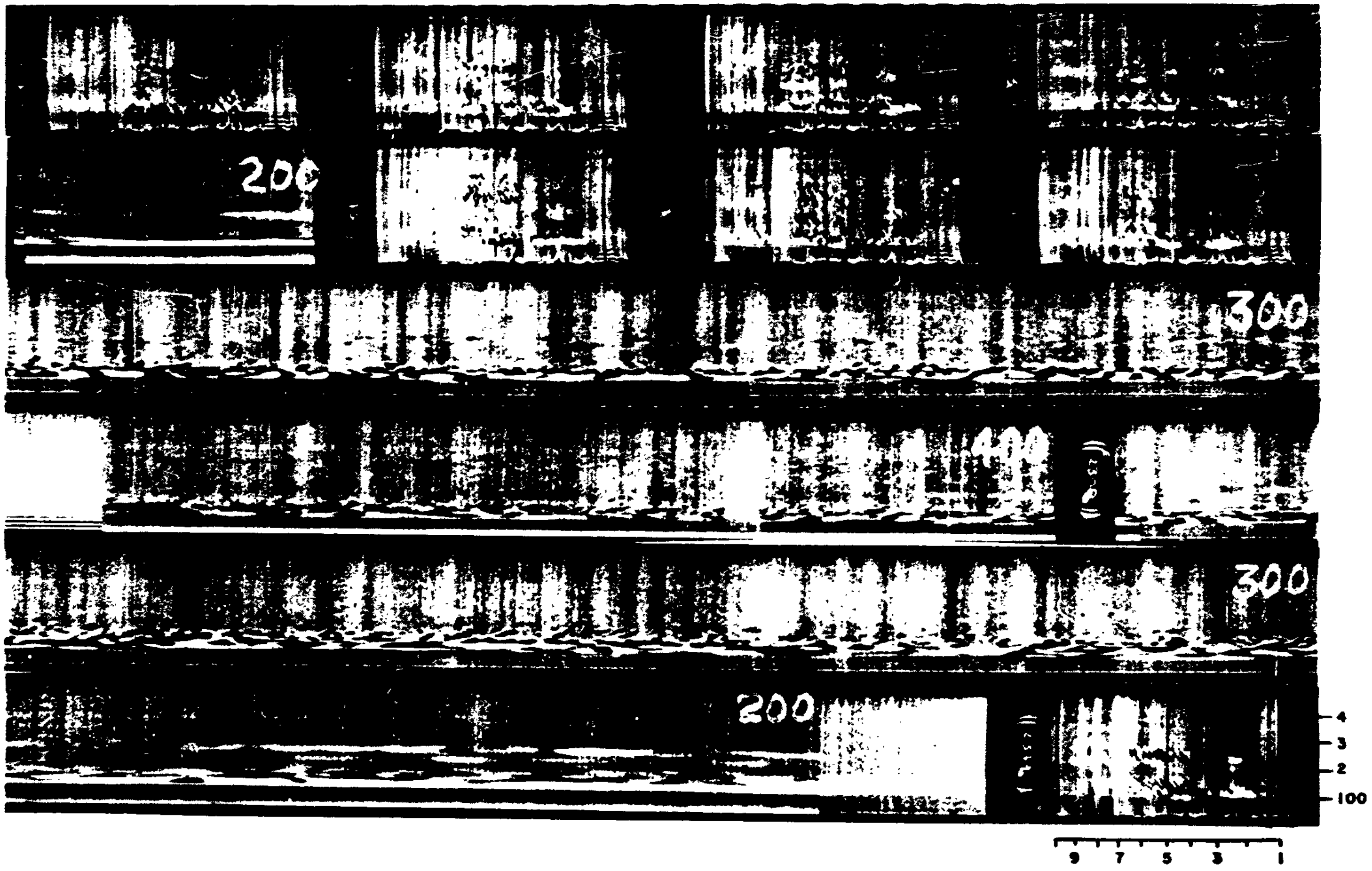
7 JUNE 1712-2157 C=0.8



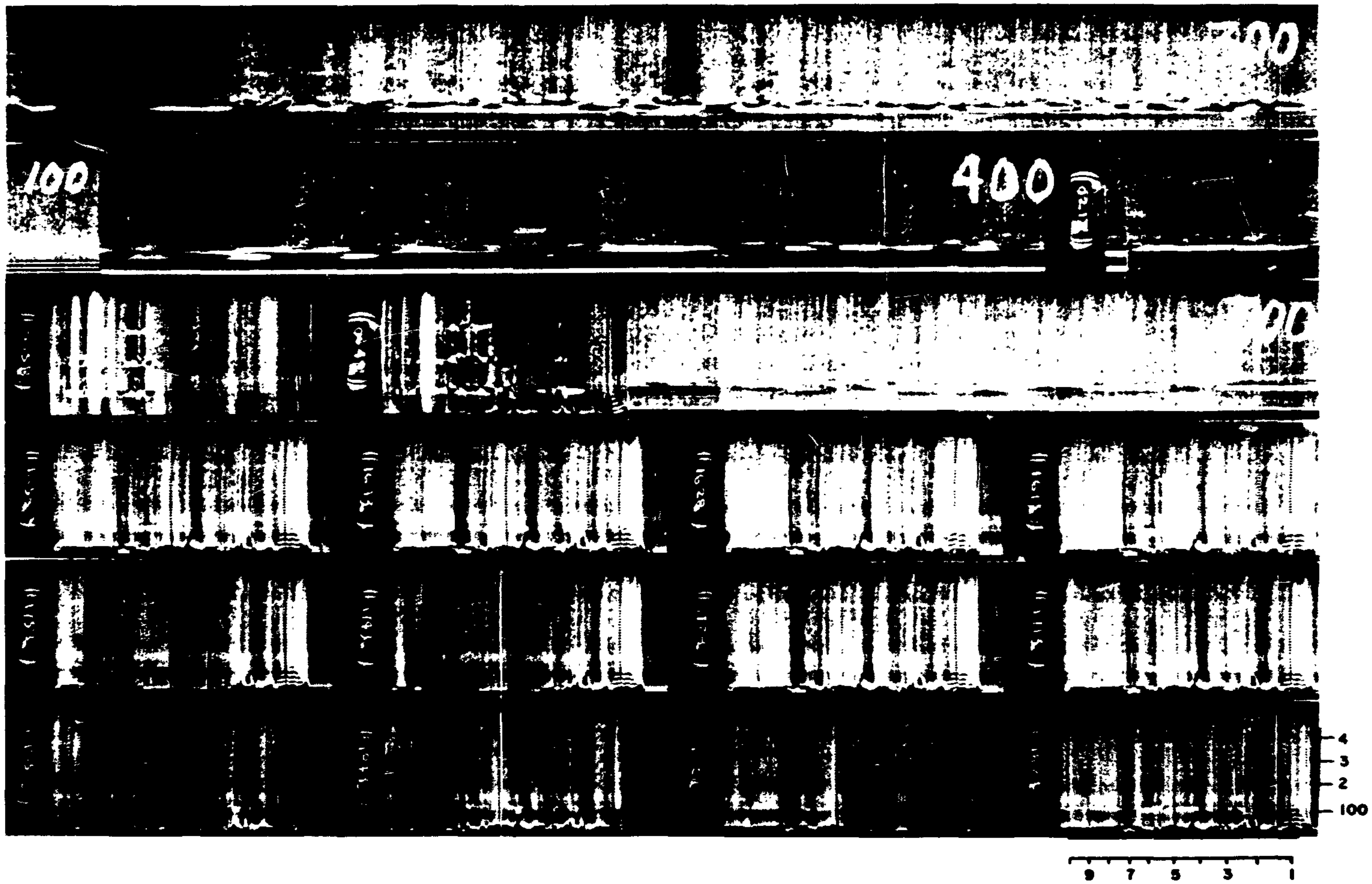
7 JUNE 2212-2357 C=0.8
8 JUNE 0012-0357 C=0.1



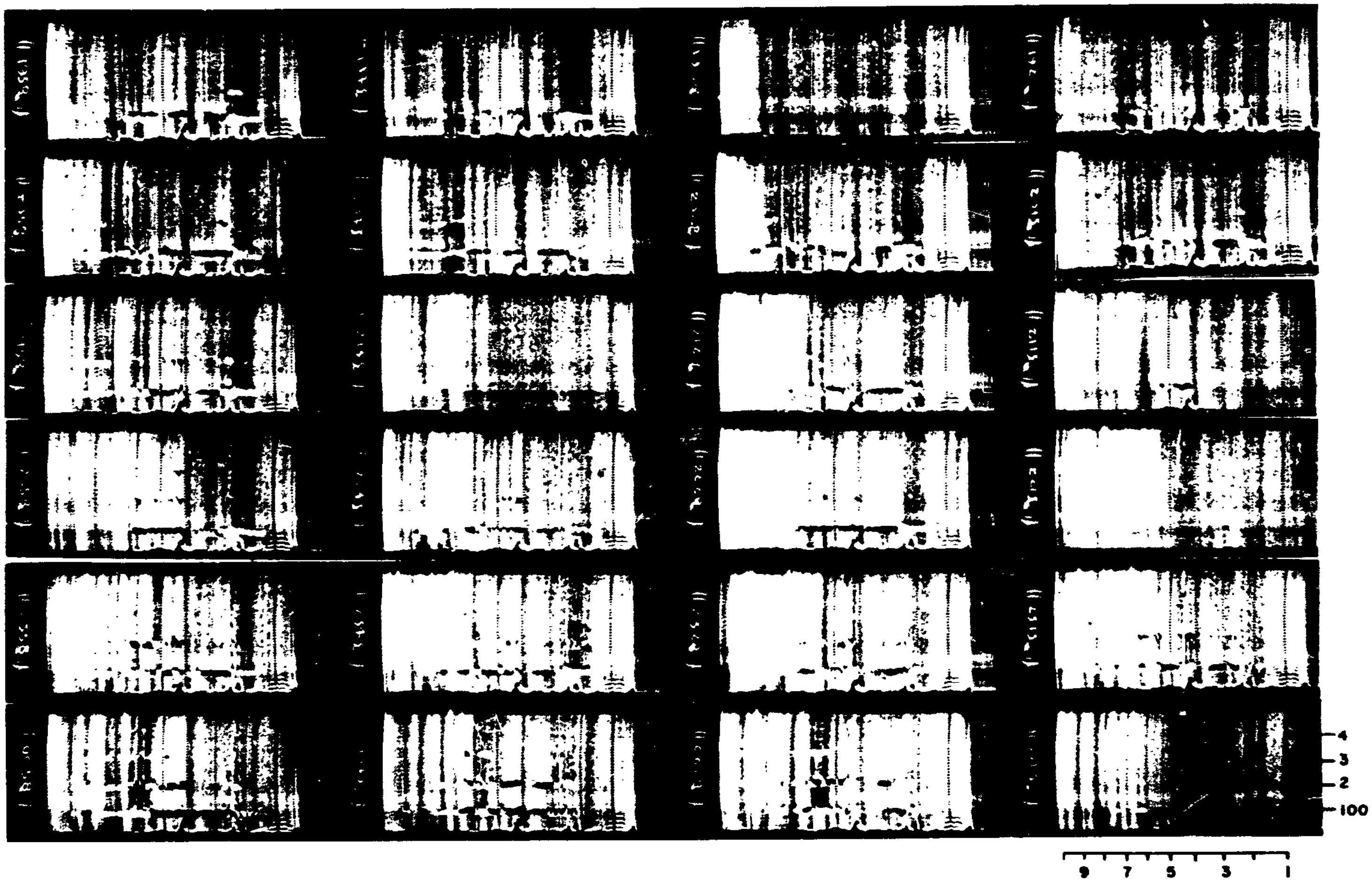
8 JUNE 0412-6557 C=0.1



8 JULY 2113-2359 C=0.7



9 JULY 0000-0058 C=0.3
9 JULY 1613-1858 C=0.3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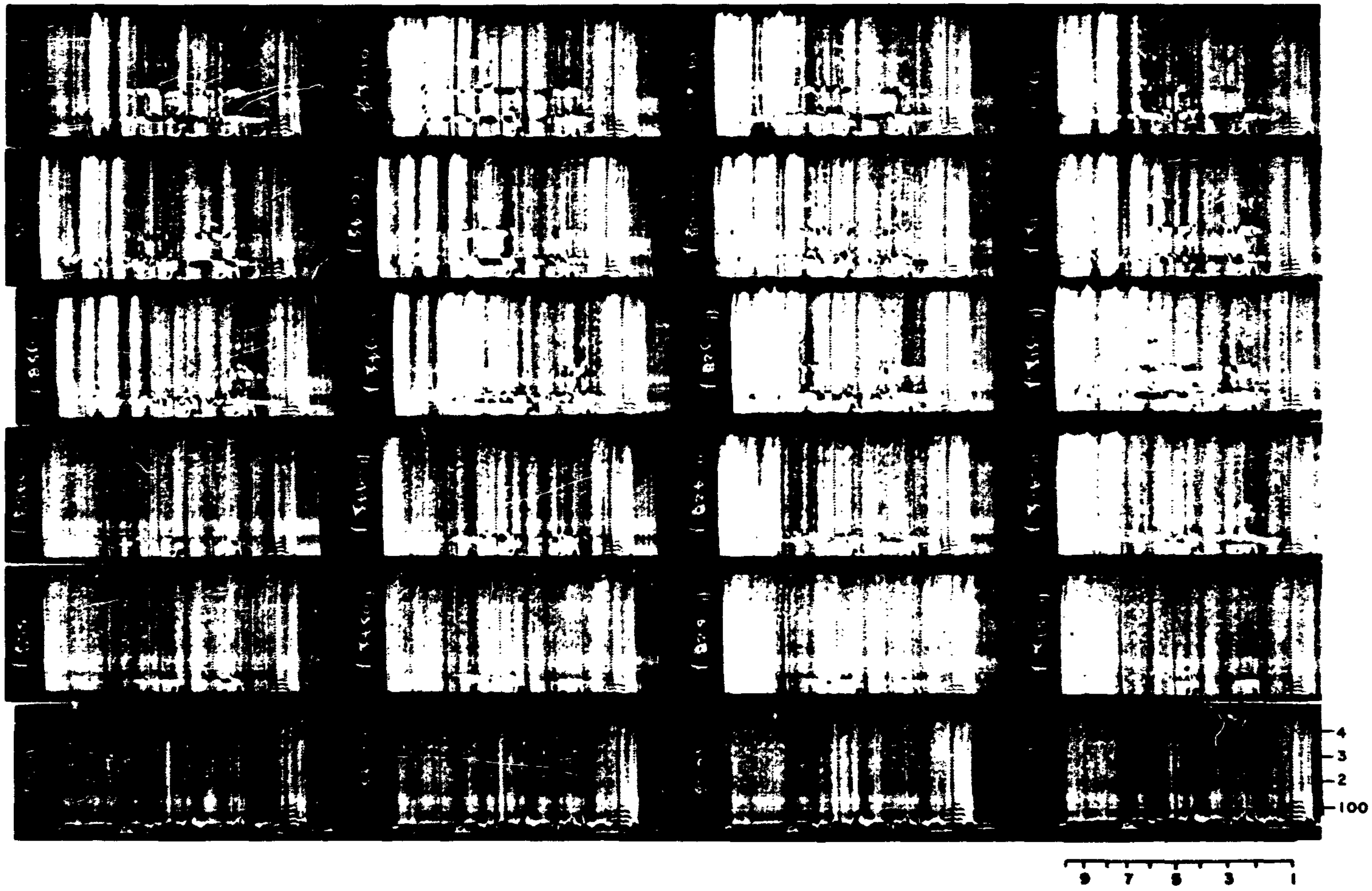
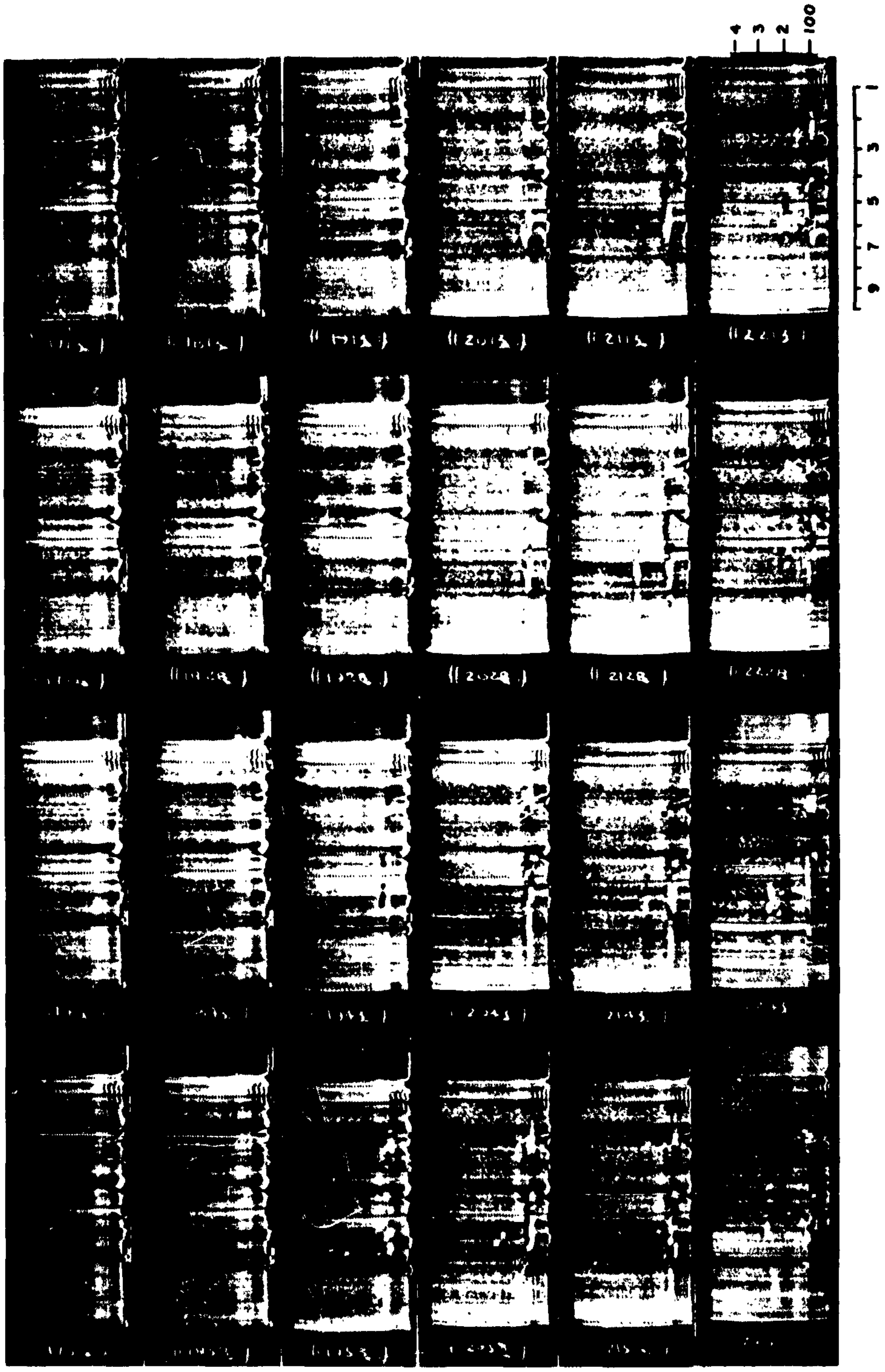
1

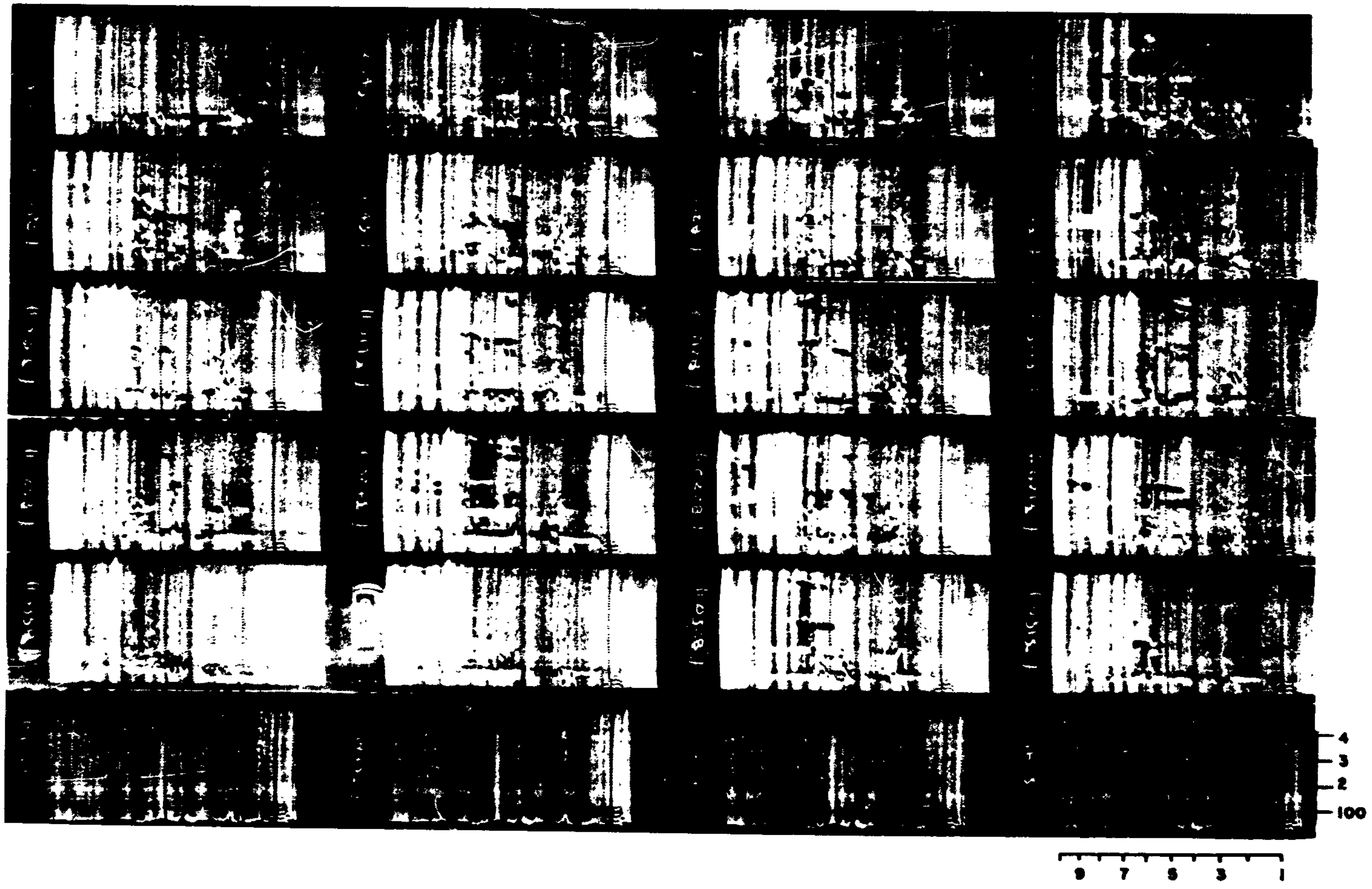
9 JULY 1922–2358 C=0.3
10 JULY 0013–0058 C=0.5



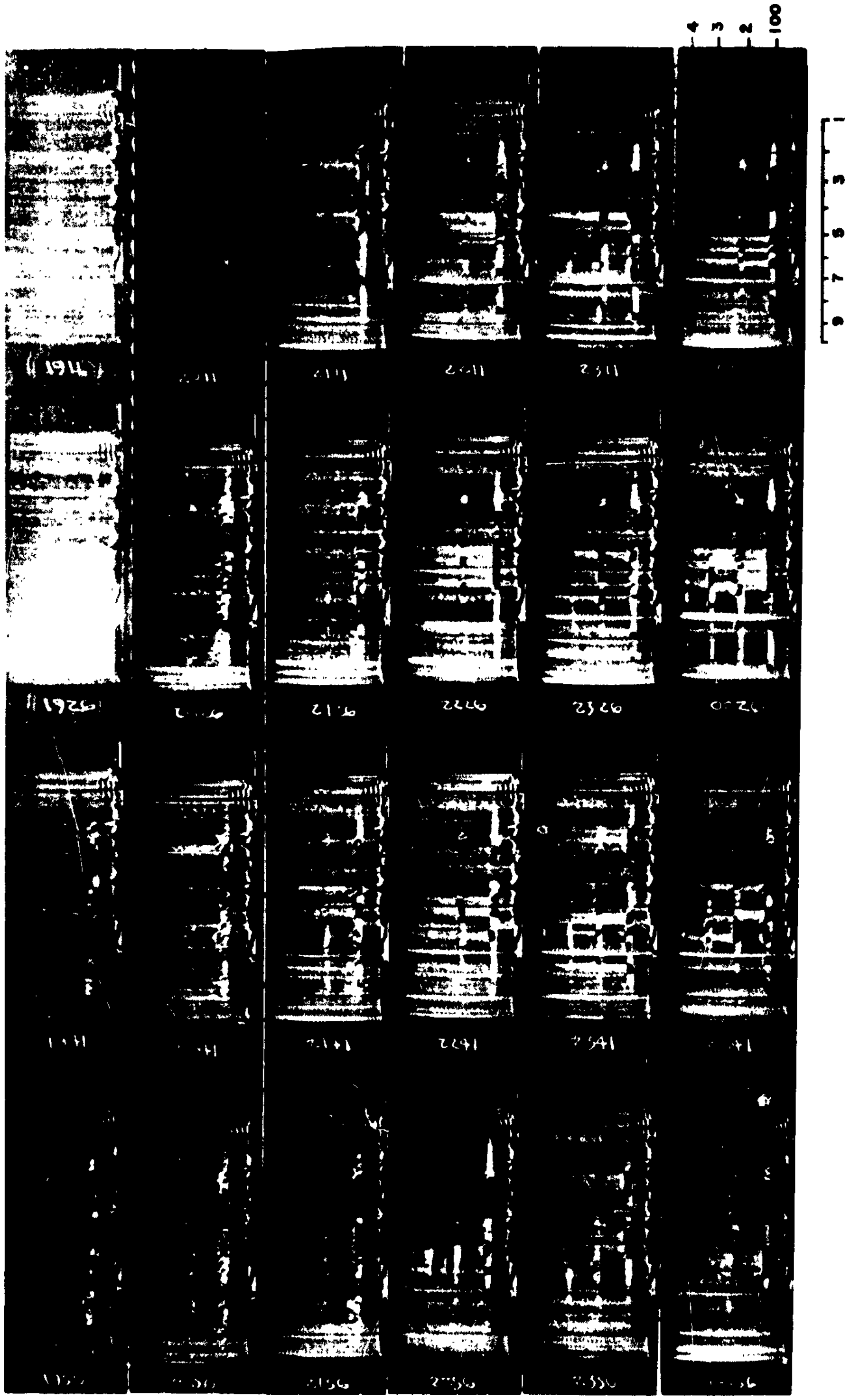
10 JULY 0113-0558 C=0.5
10 JULY 1613-1658 C=0.5



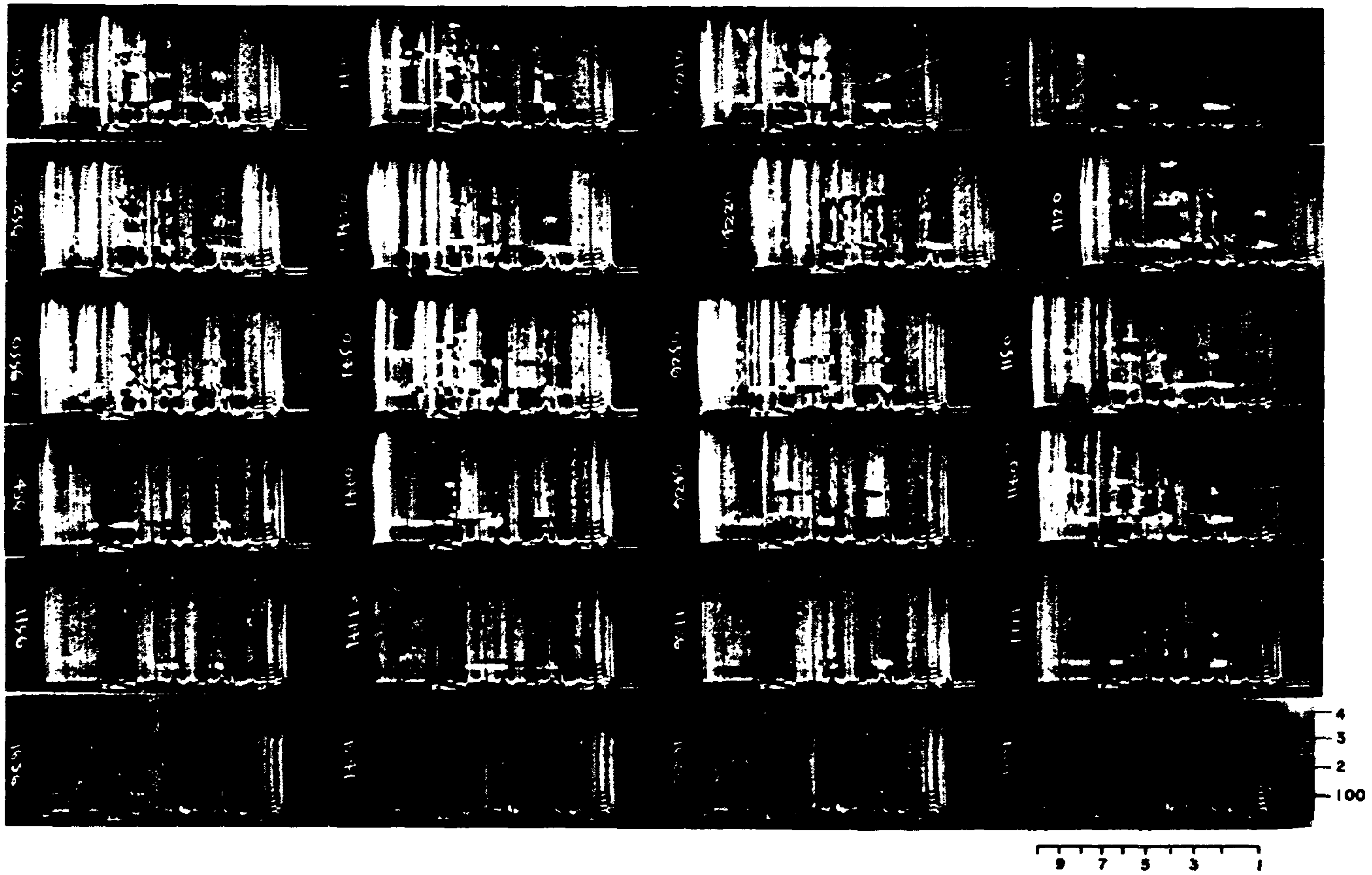
10 JULY 1713-2258 C=0.5



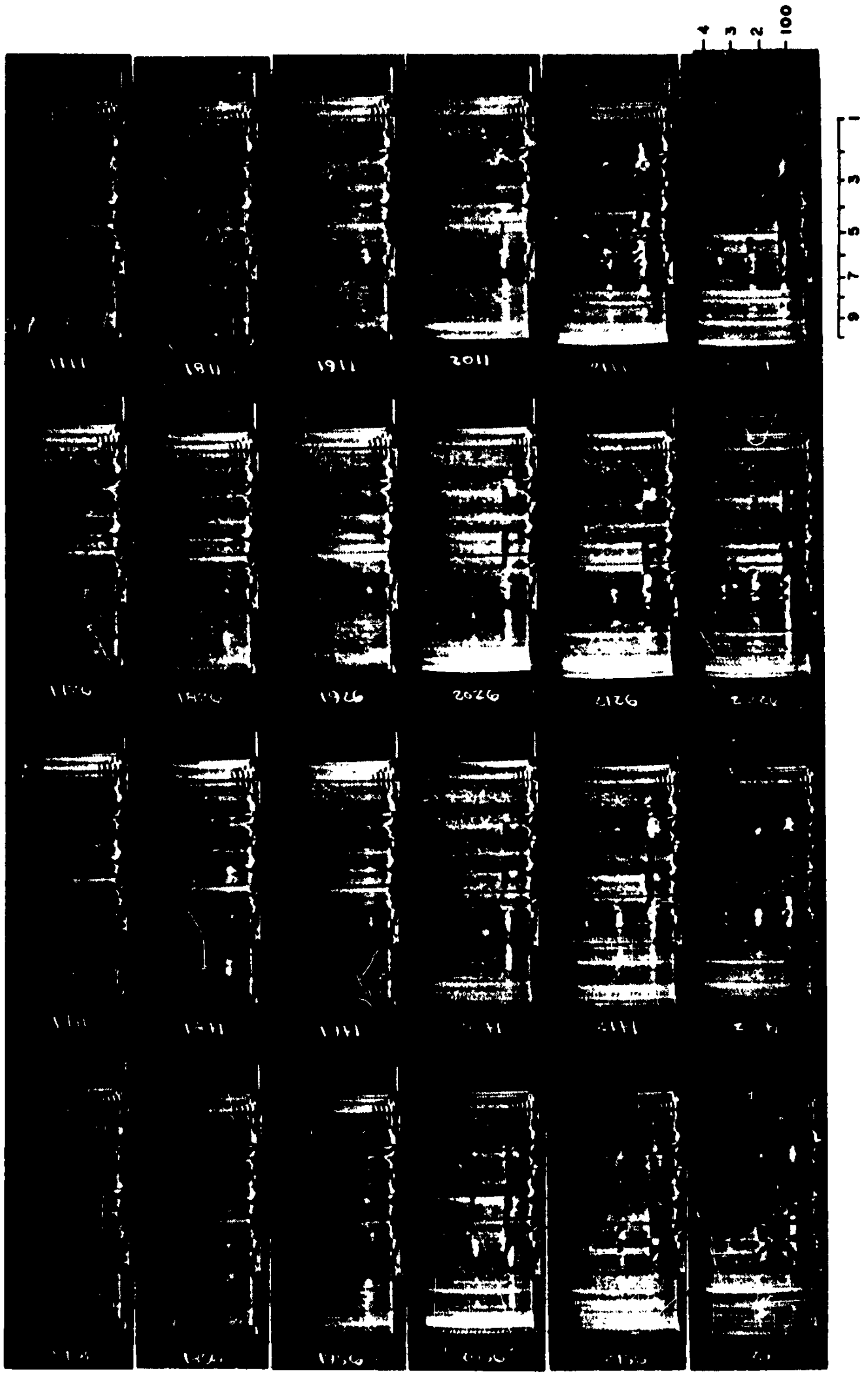
10 JULY 2313-2358 C=0.5
11 JULY 0013-0358 C=0.6
11 JULY 1813-1858 C=0.6



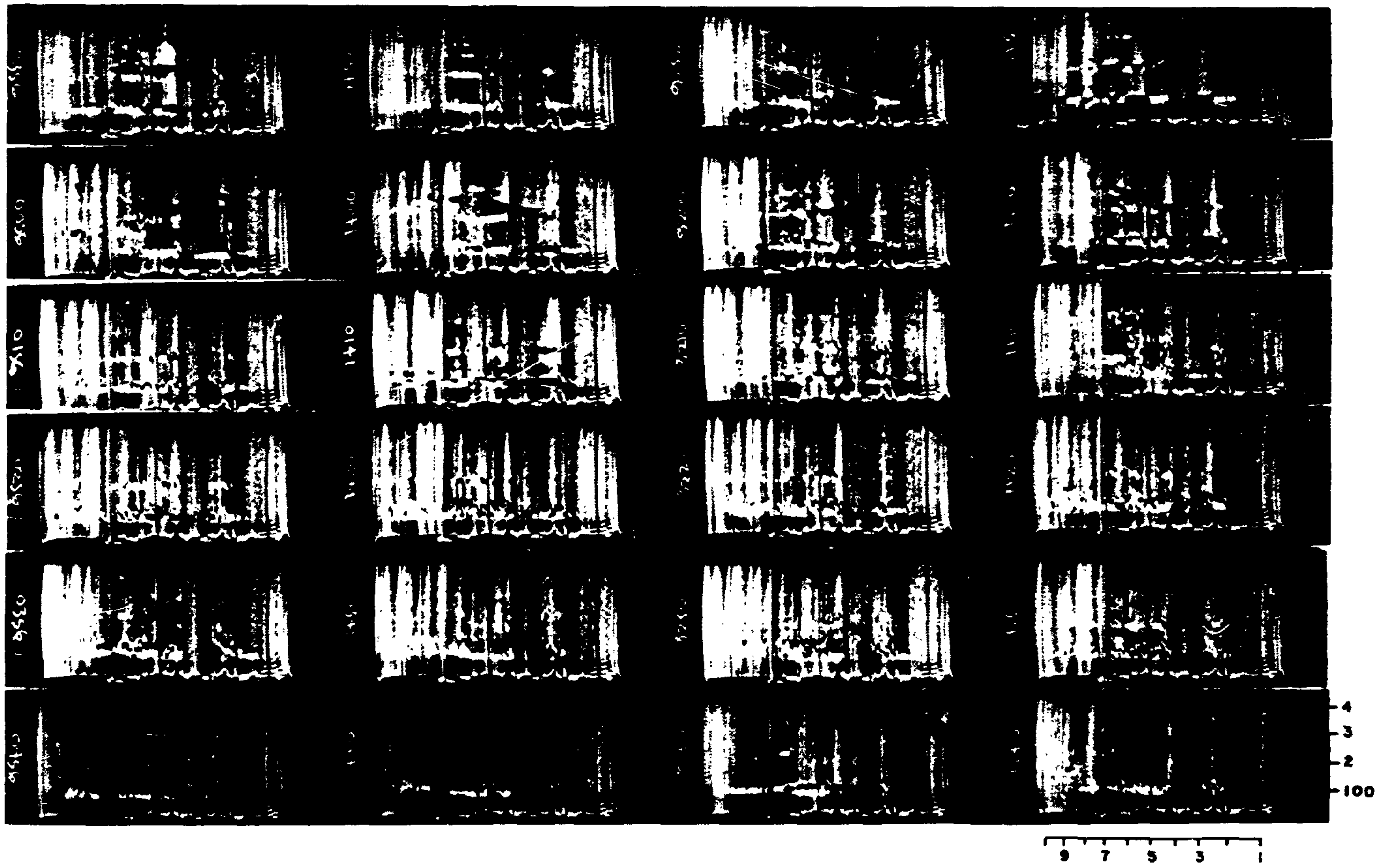
12 JULY 1911-2356 C=0.5
13 JULY 0011-0056 C=0.6



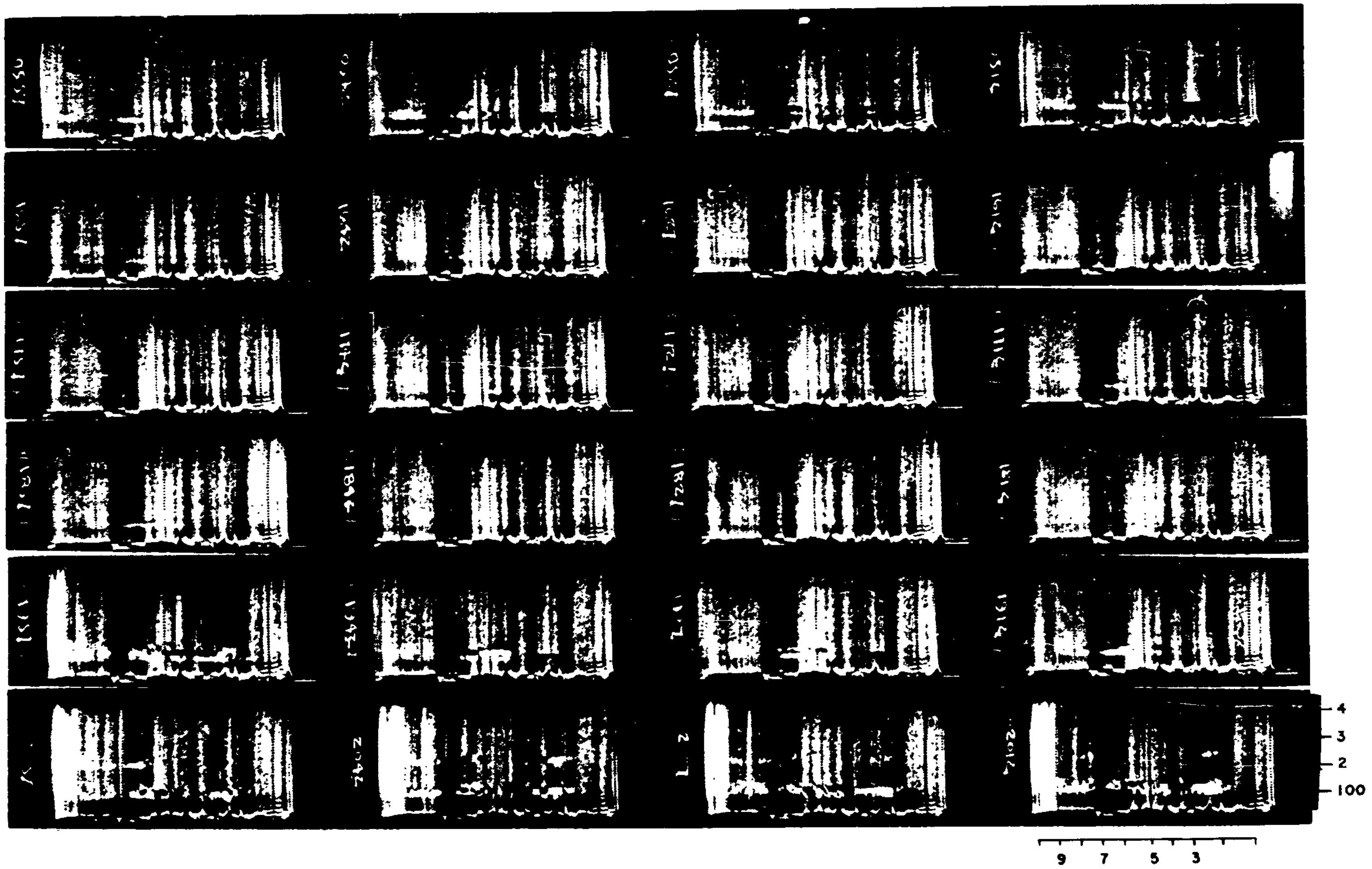
13 JULY 0111 – 0556 C = 0.6
13 JULY 1611 – 1656 C = 0.6



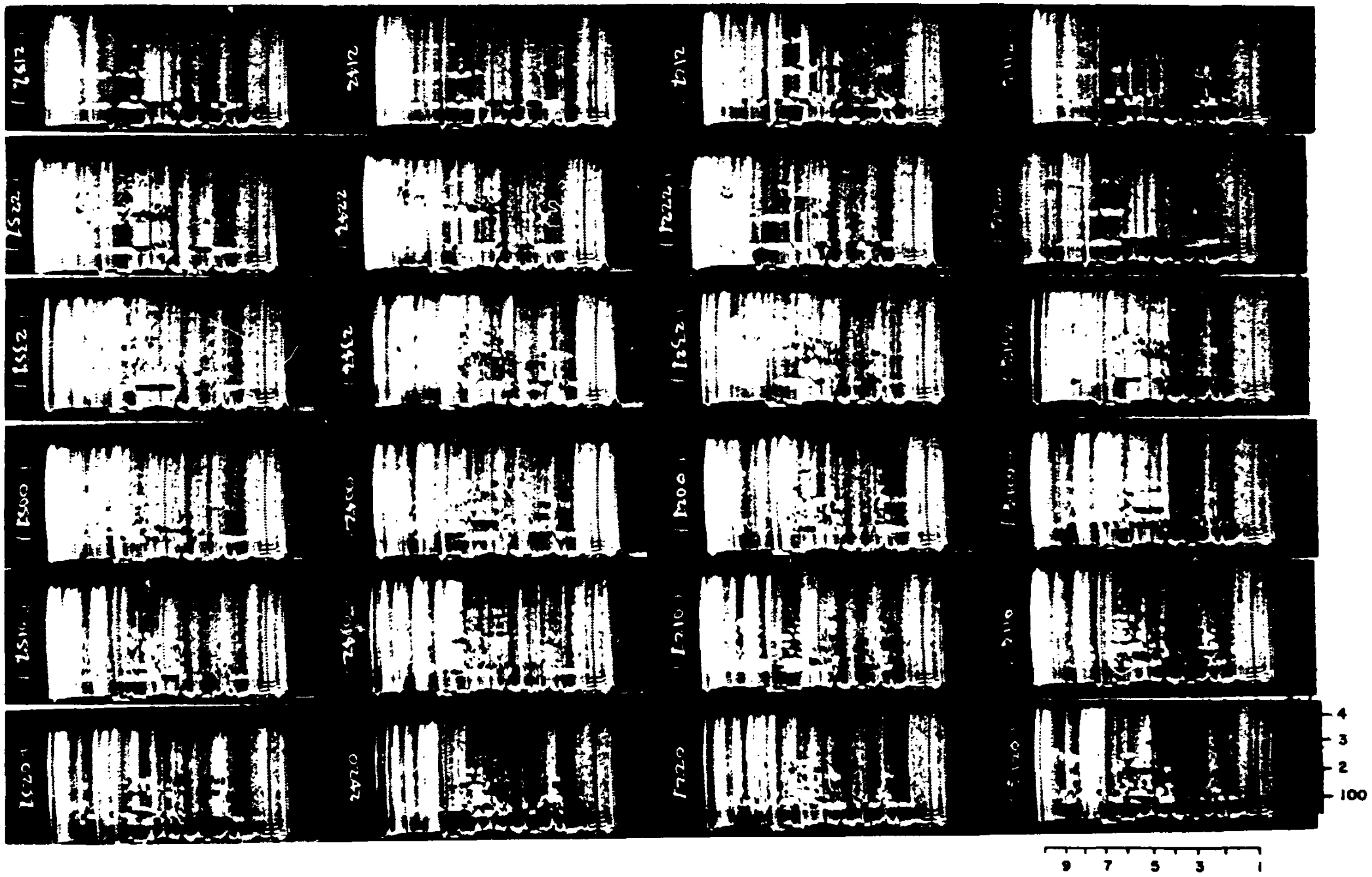
13 JULY 1711-2256 C=0.6



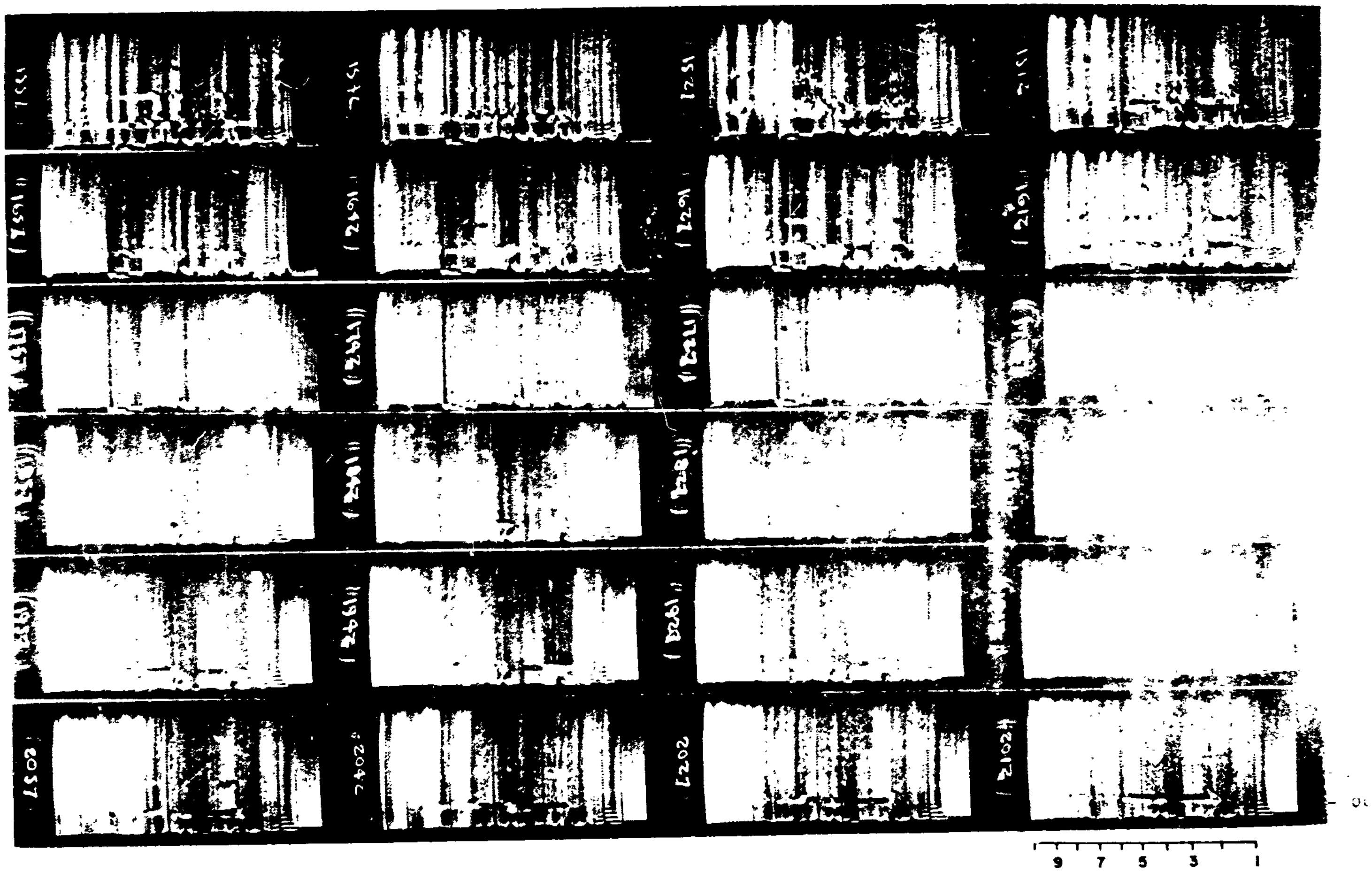
13 JULY 2311-2356 C=0.6
14 JULY 0011-0456 C=0.7



14 JULY 0511 - 0556 C = 0.7
14 JULY 1612 - 2057 C = 0.7



14 JULY 2112 - 2357 C = 0.7
15 JULY 0012 - 0257 C = 0.3


1512
1612
2012
1527
1627
1727
1827
1927
2027
1542
1642
1742
1842
1942
2042
1557
1657
2057
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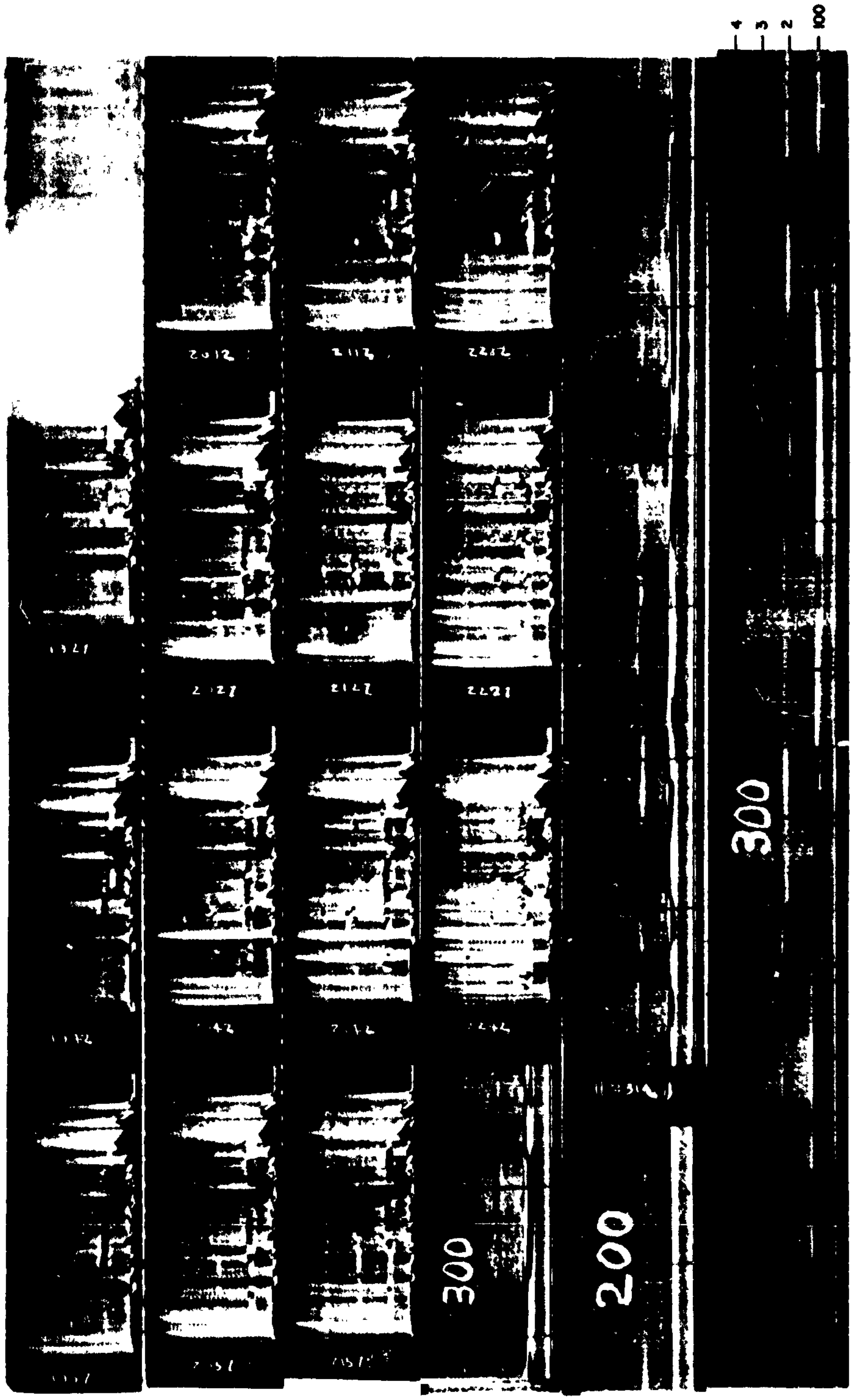
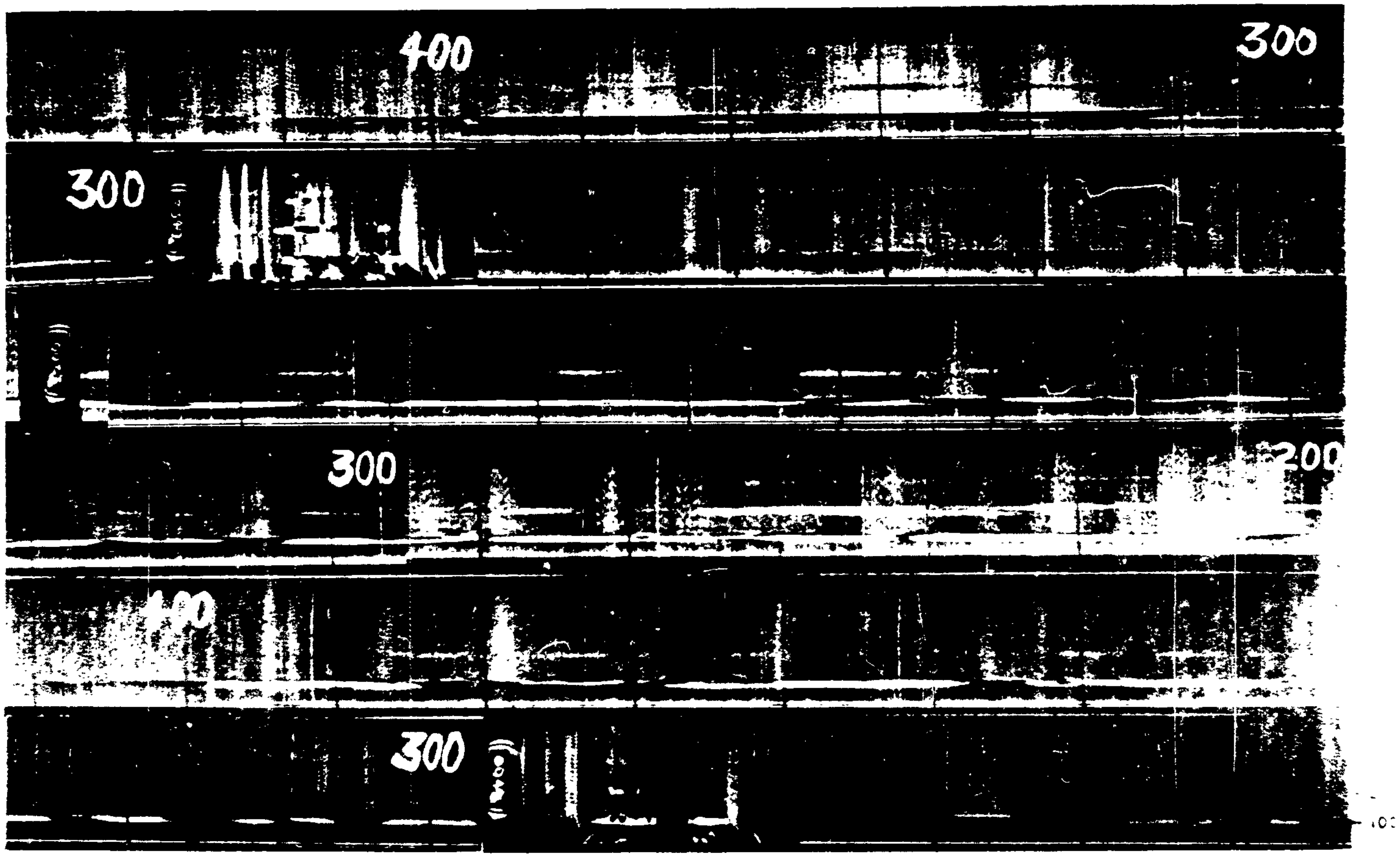
1

15 JULY 0312 – 0557 C = 0.3
20 JULY 1812 – 2057 C = 1.0

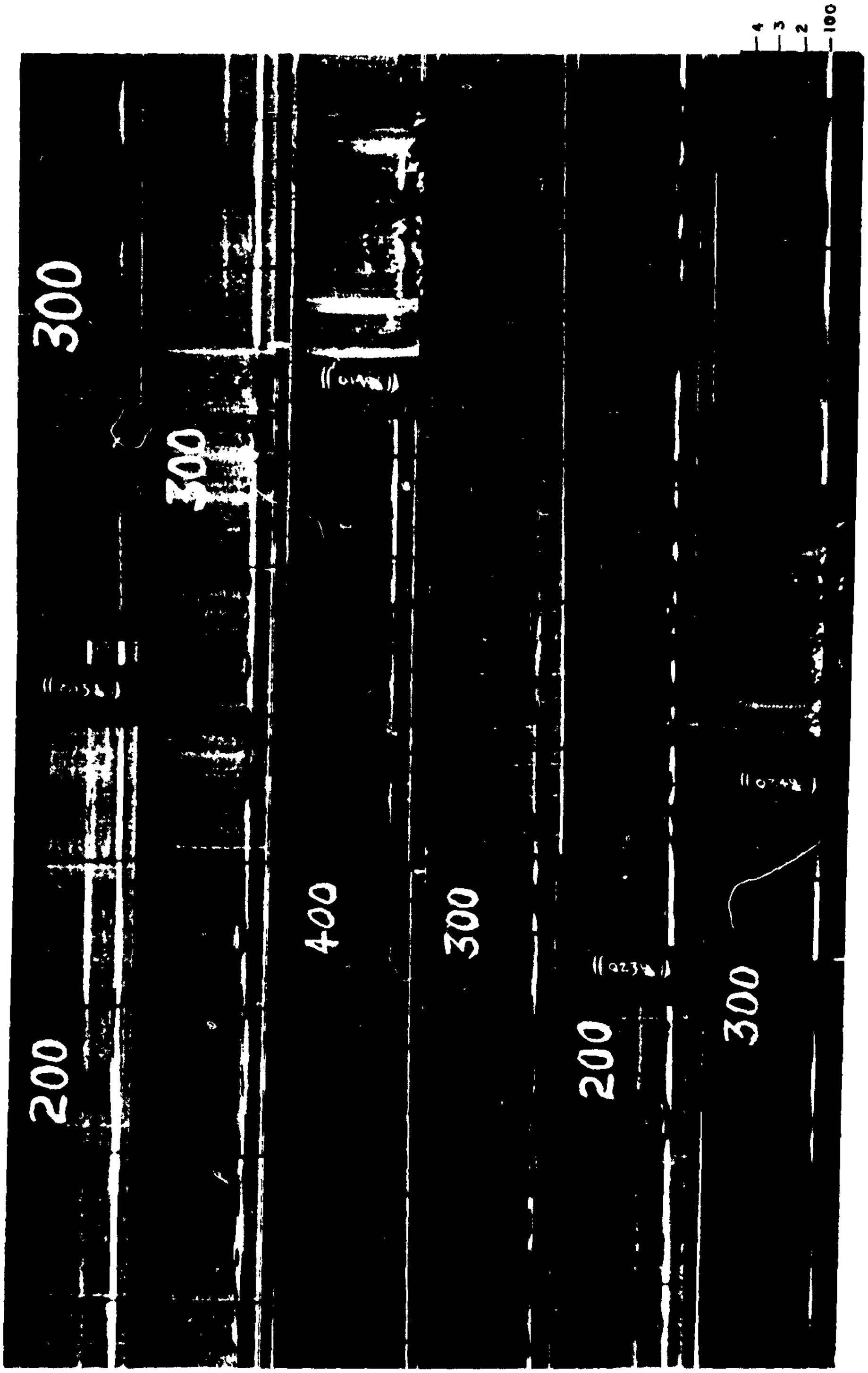


17 JULY 1912 - 2324

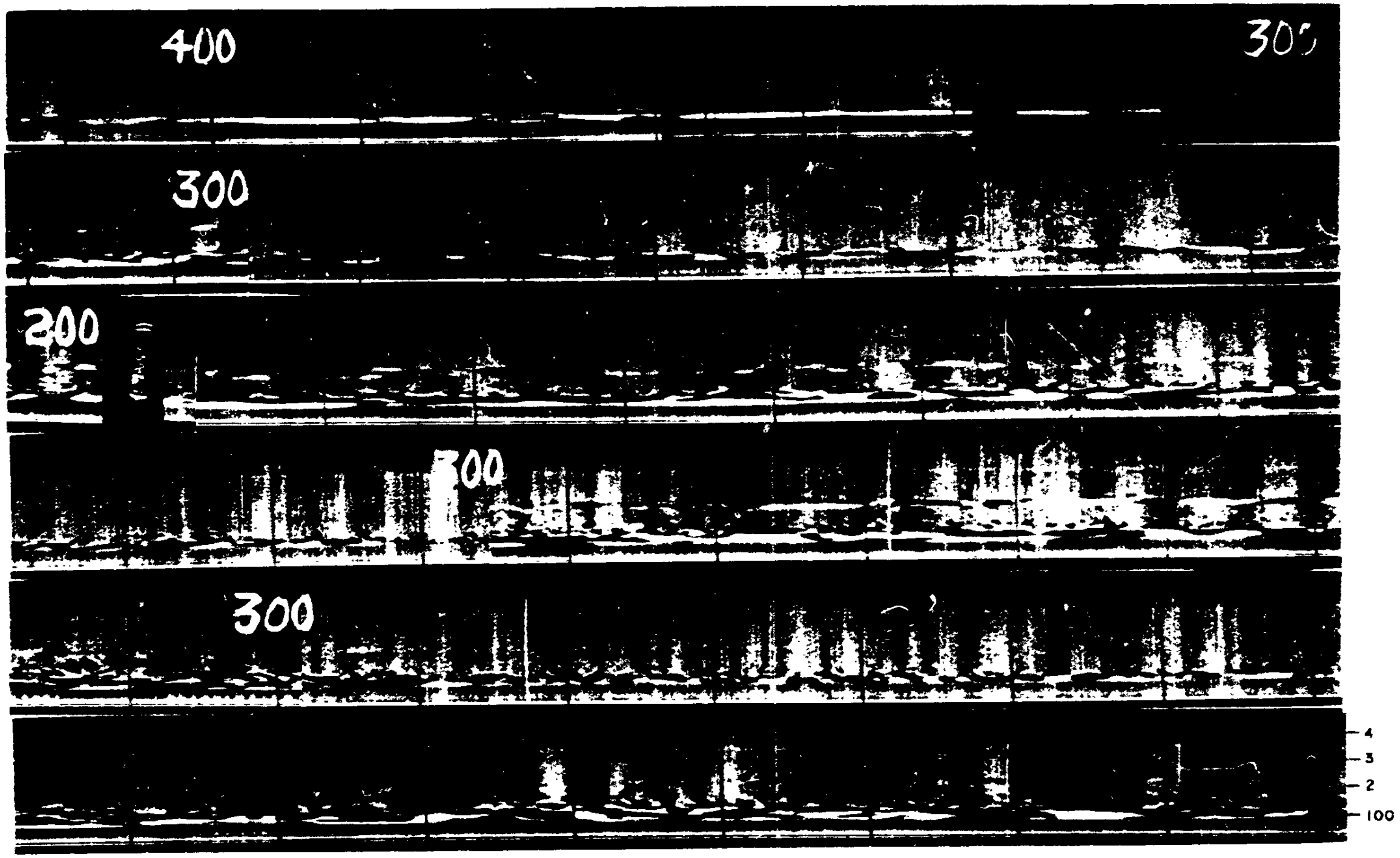
C = 0.1



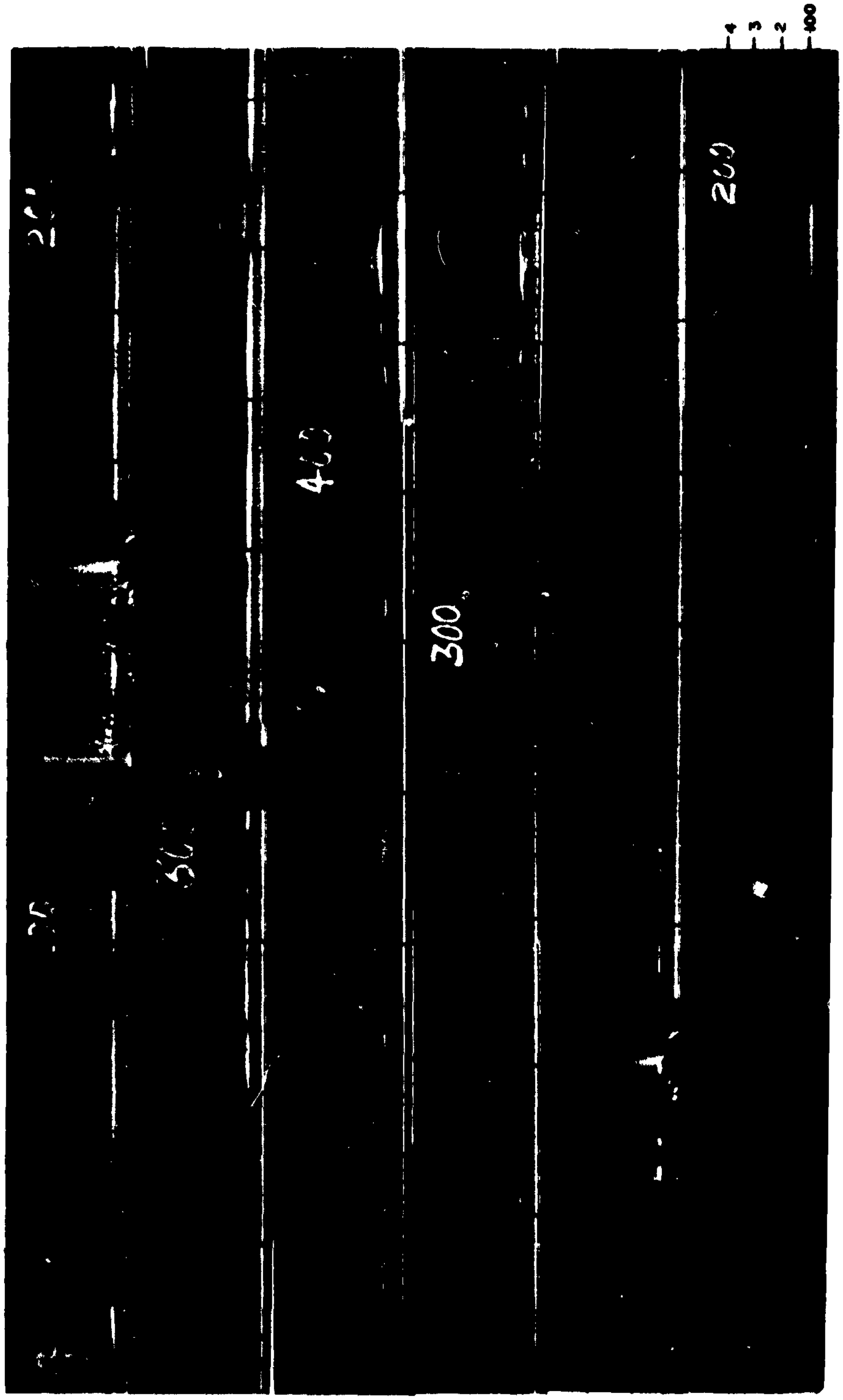
17 JULY 2325-2359 C=0.1
18 JULY 0000-0052 C=0.2



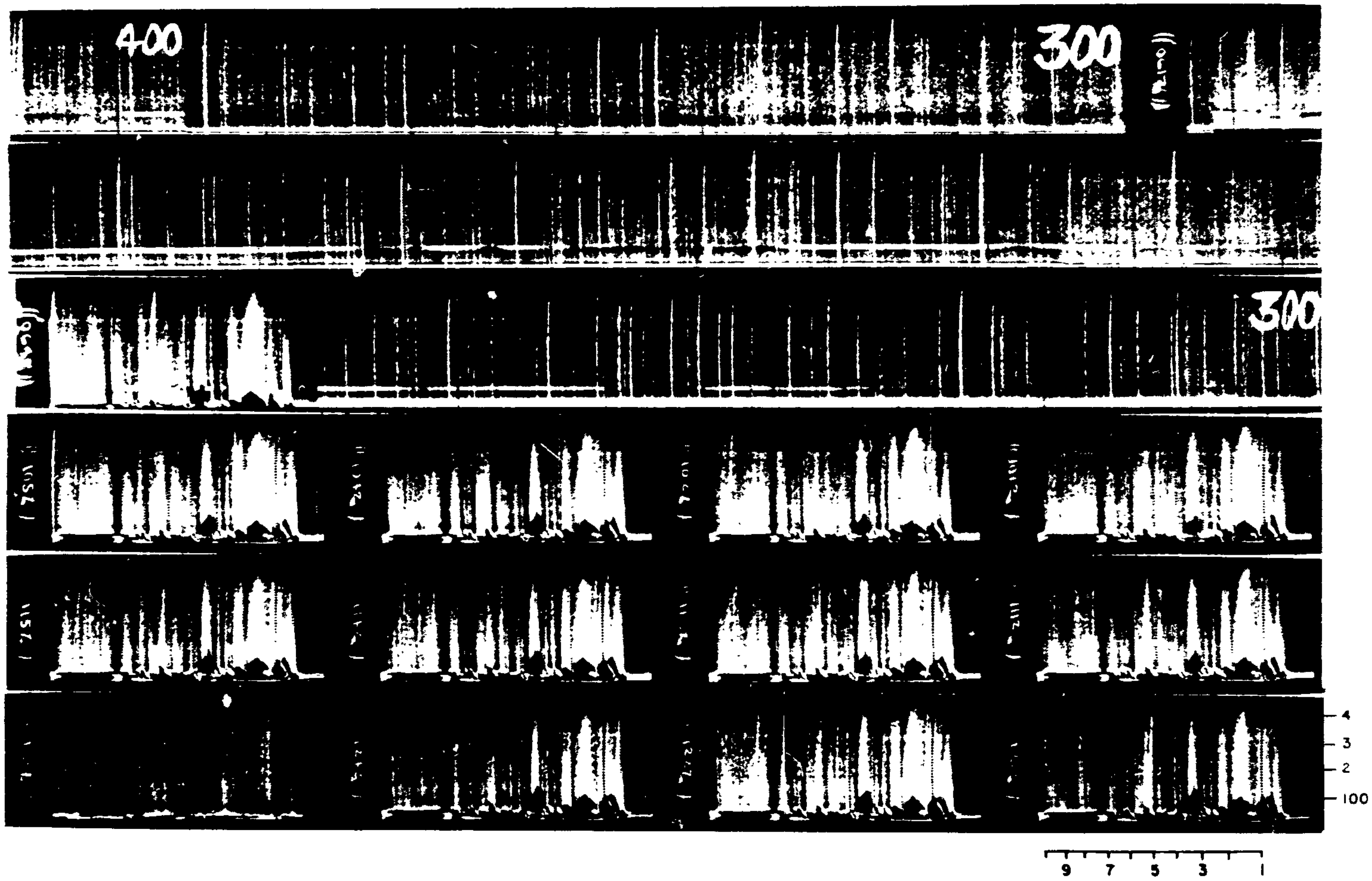
18 JULY 0053-0253 C=0.2



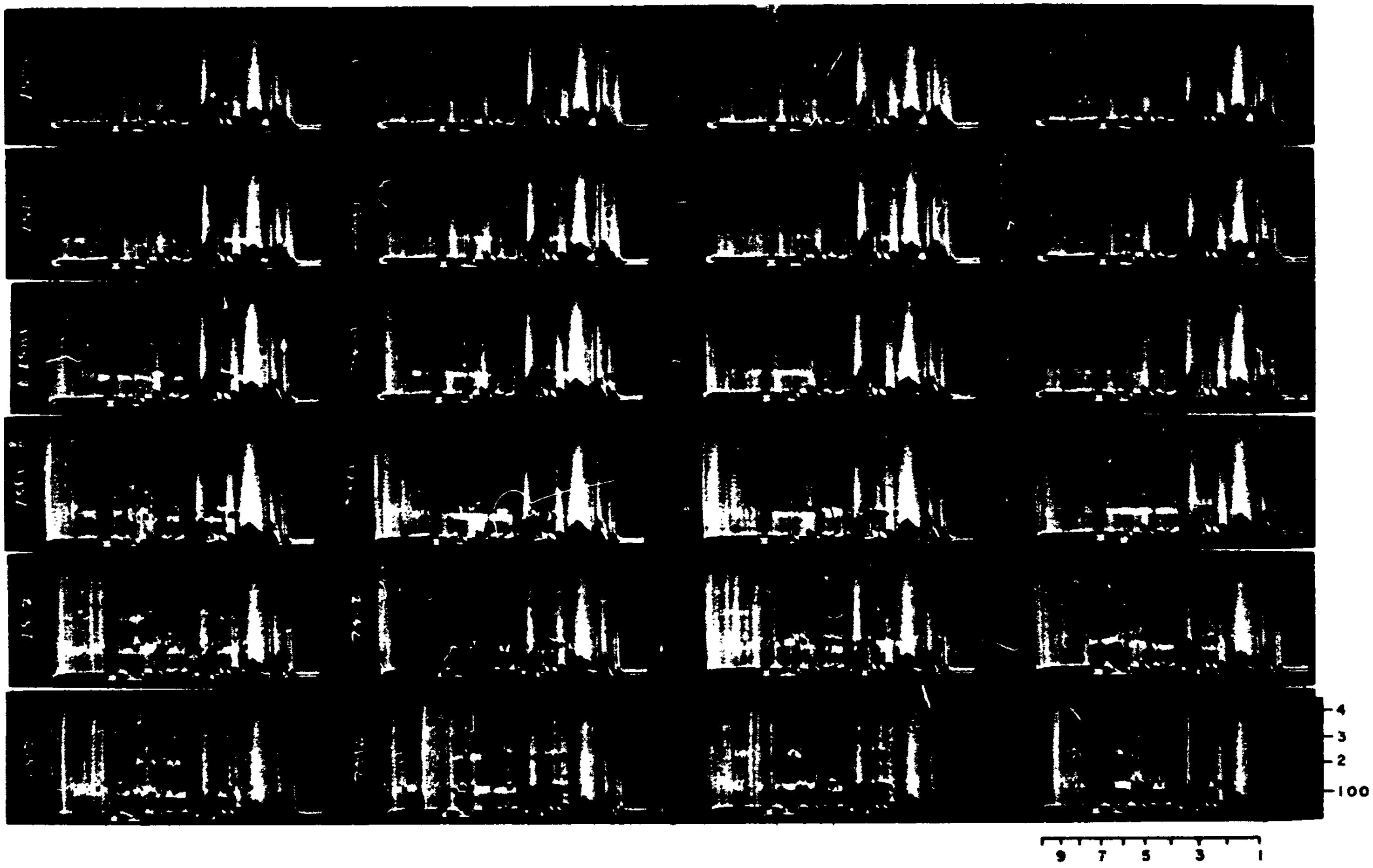
18 JULY 0253-0424 C=0.2



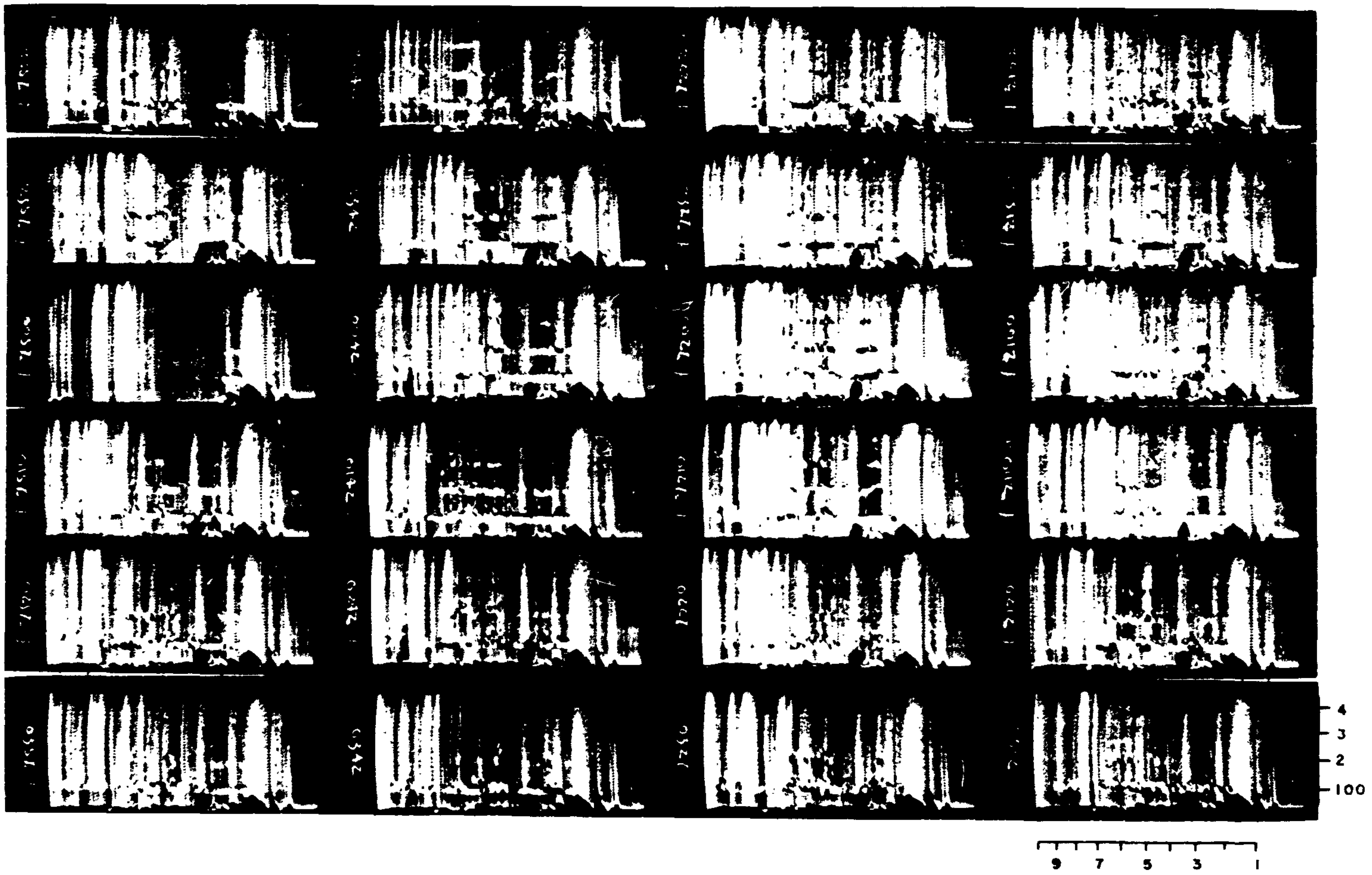
18 JULY 0424–0611 C=0.2



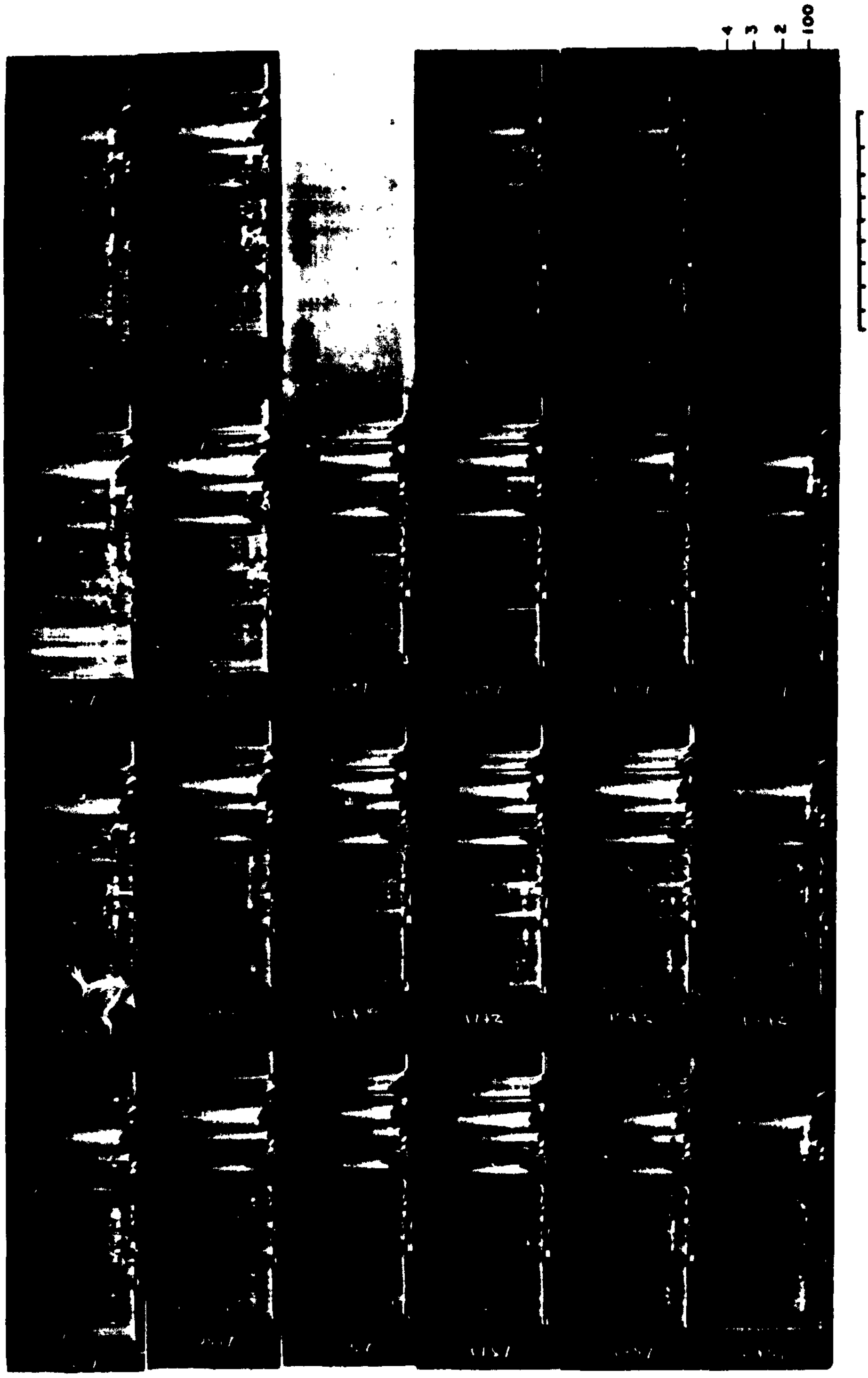
18 JULY 0612-0649 C=0.2
18 JULY 1016-1257 C=0.2



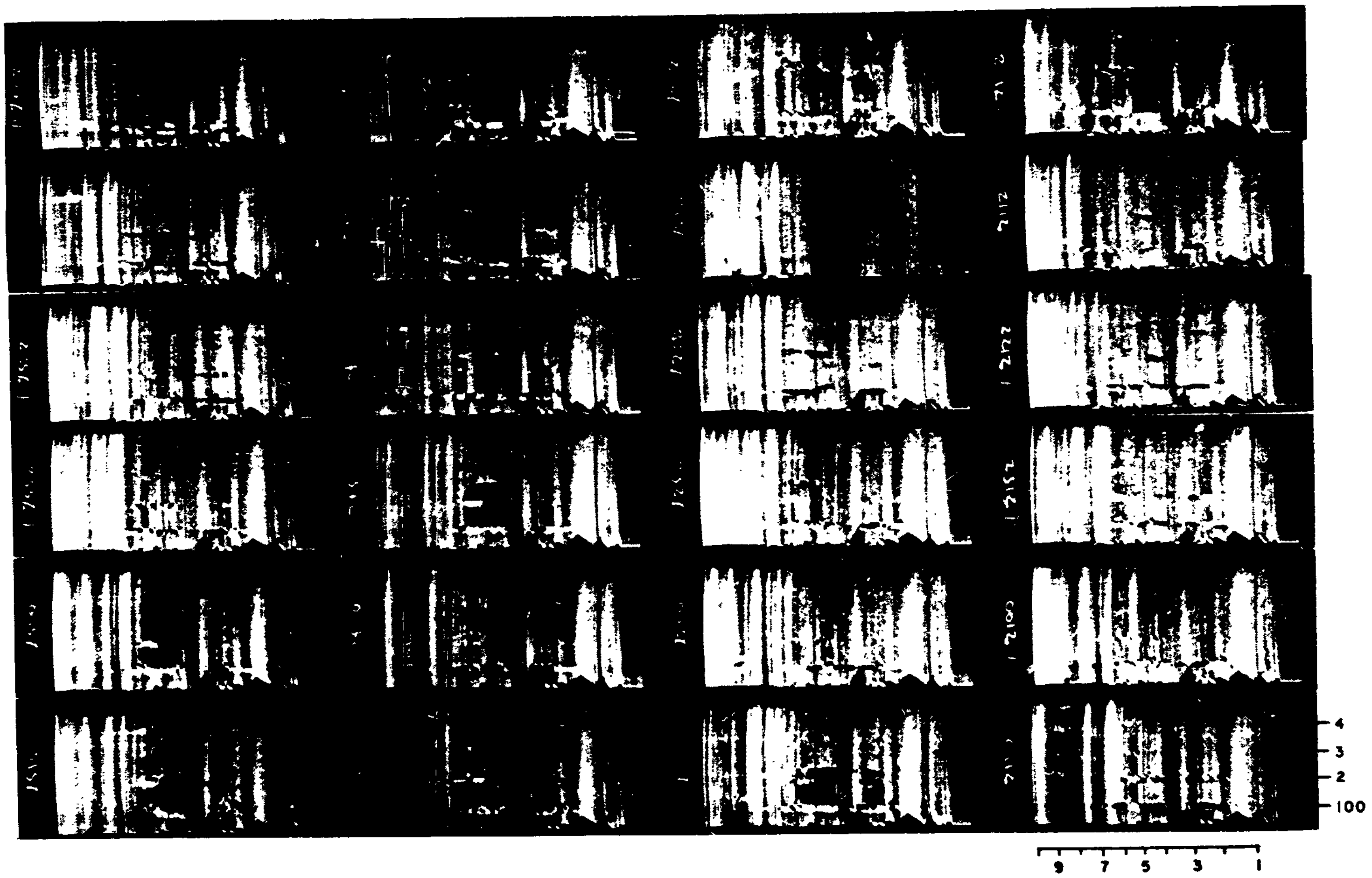
18 JULY 1612–2157 C=0.2



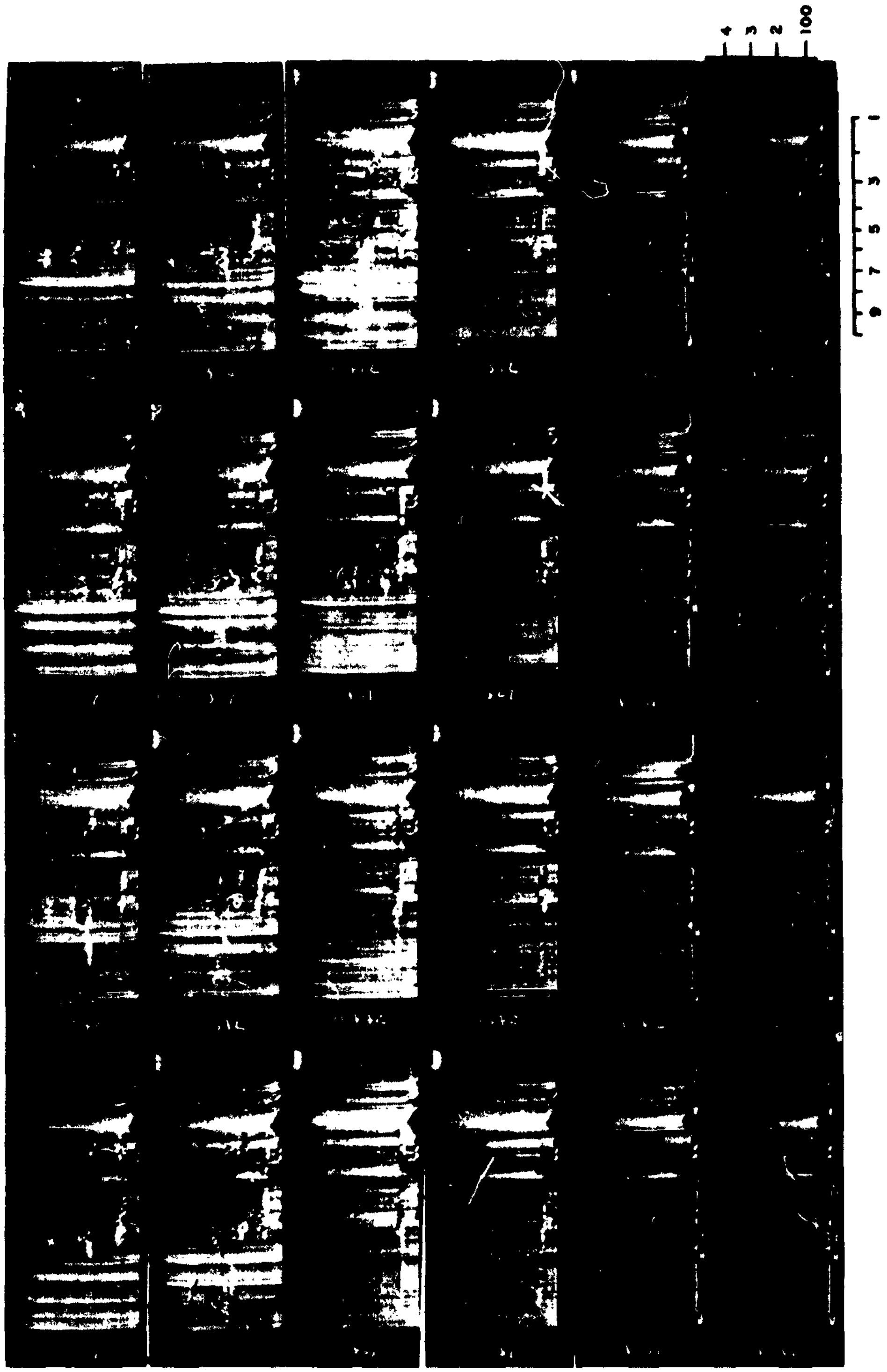
18 JULY 2212-2357 C=0.2
19 JULY 0012-0357 C=0.8



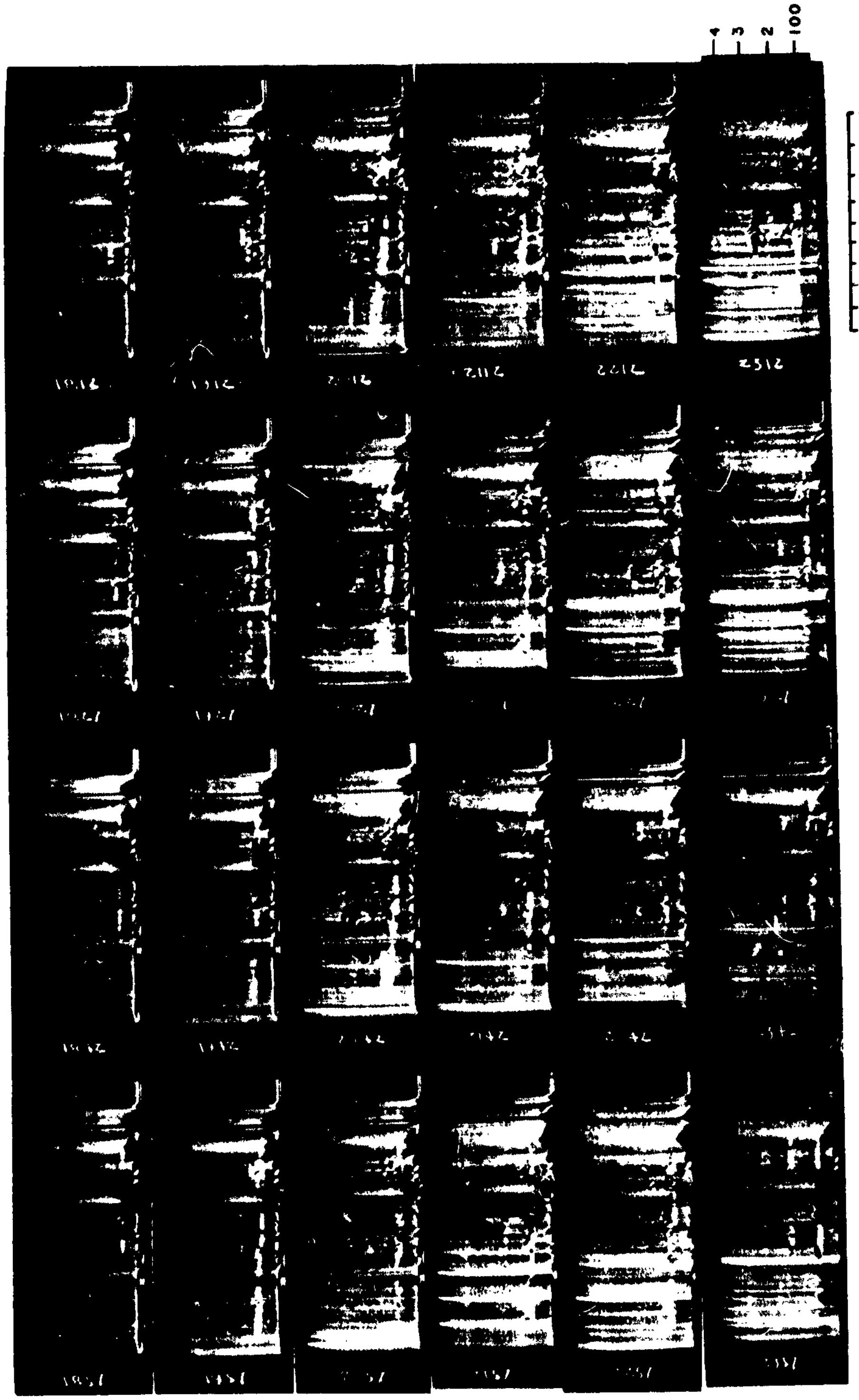
19 JULY 0412-0557 C:0.8
19 JULY 1612-1957 C:0.8



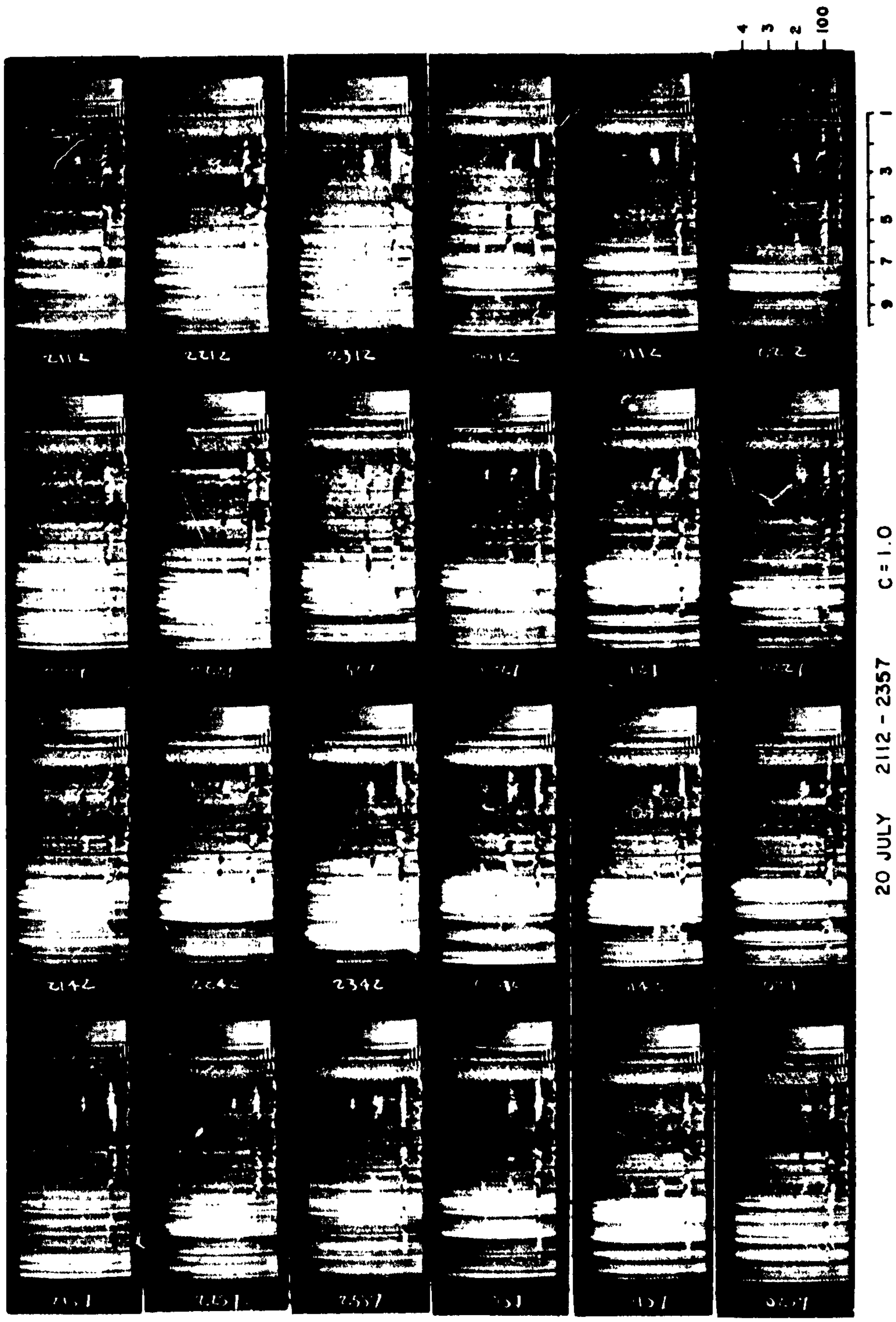
19 JULY 2012-2357 C=0.8
20JULY 0012-0157 C=1.0



20 JULY 0212–0557 C=1.0
20 JULY 1612–1757 C=1.0



20 JULY 1812-2357 C=1.0


100
2
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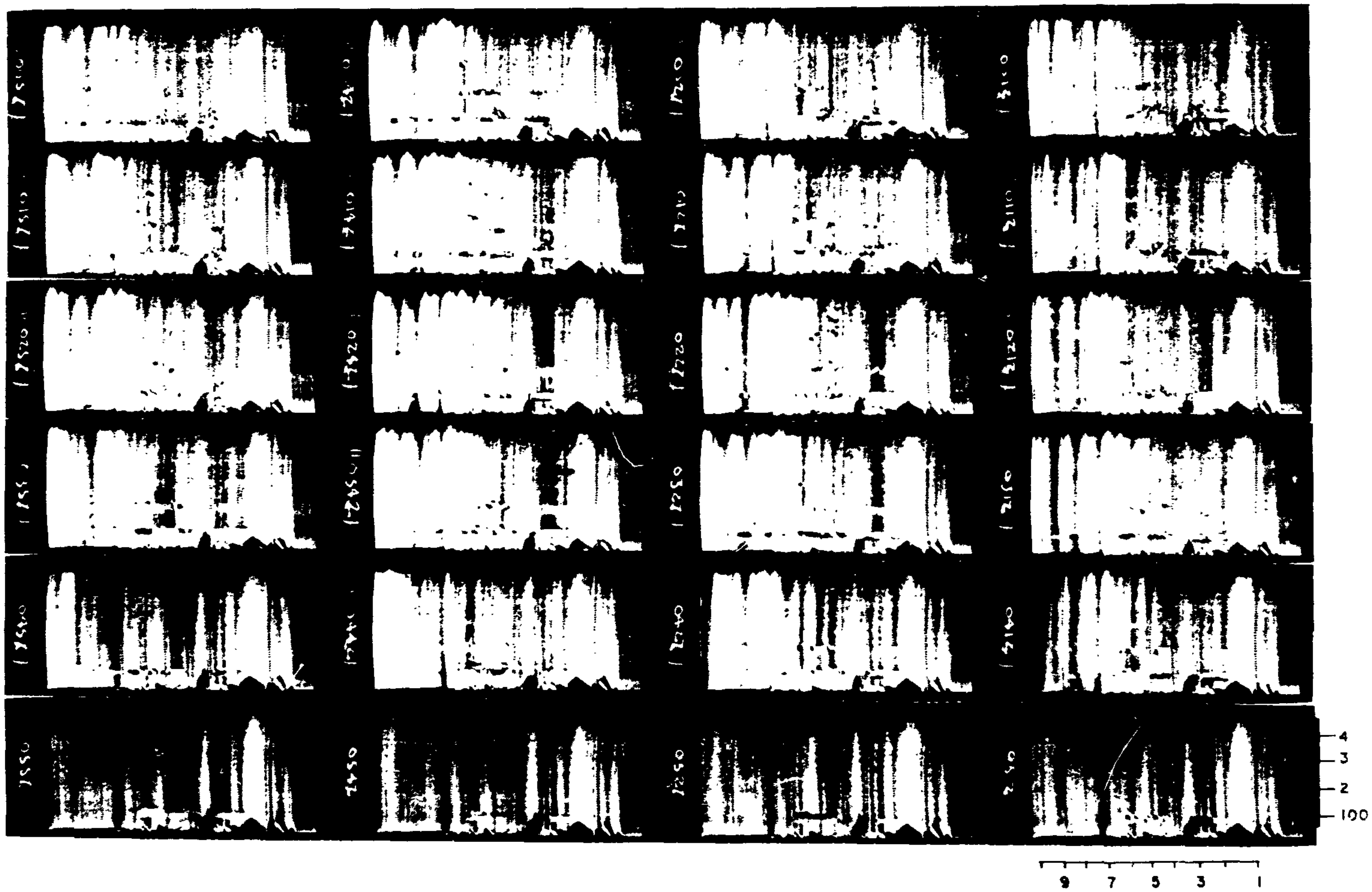
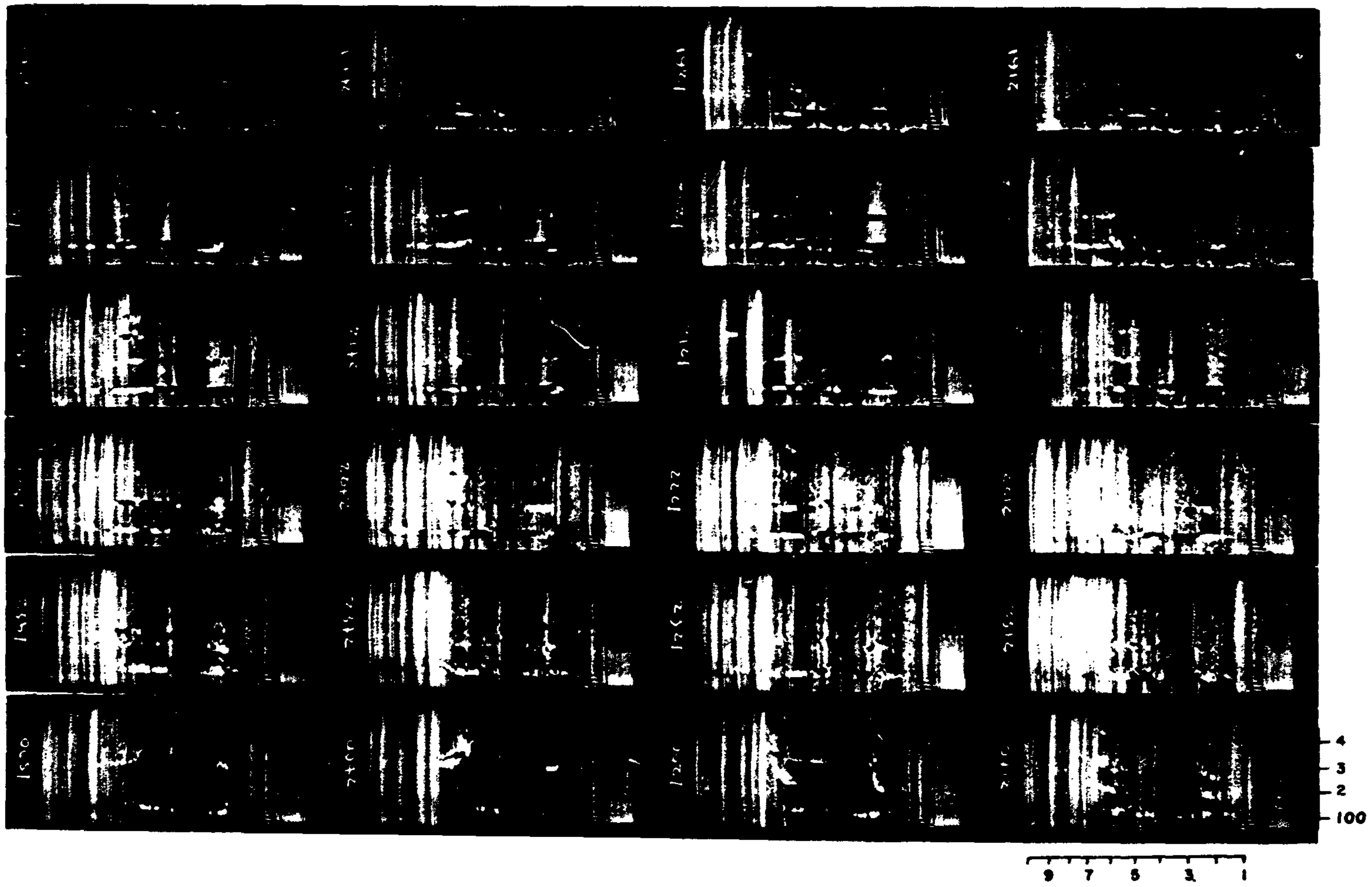
9
2112
2212
2312
2142
2242
2342
2257
2357

20 JULY 2112 - 2357 C = 1.0
21 JULY 0012 - 0257 C = 0.8

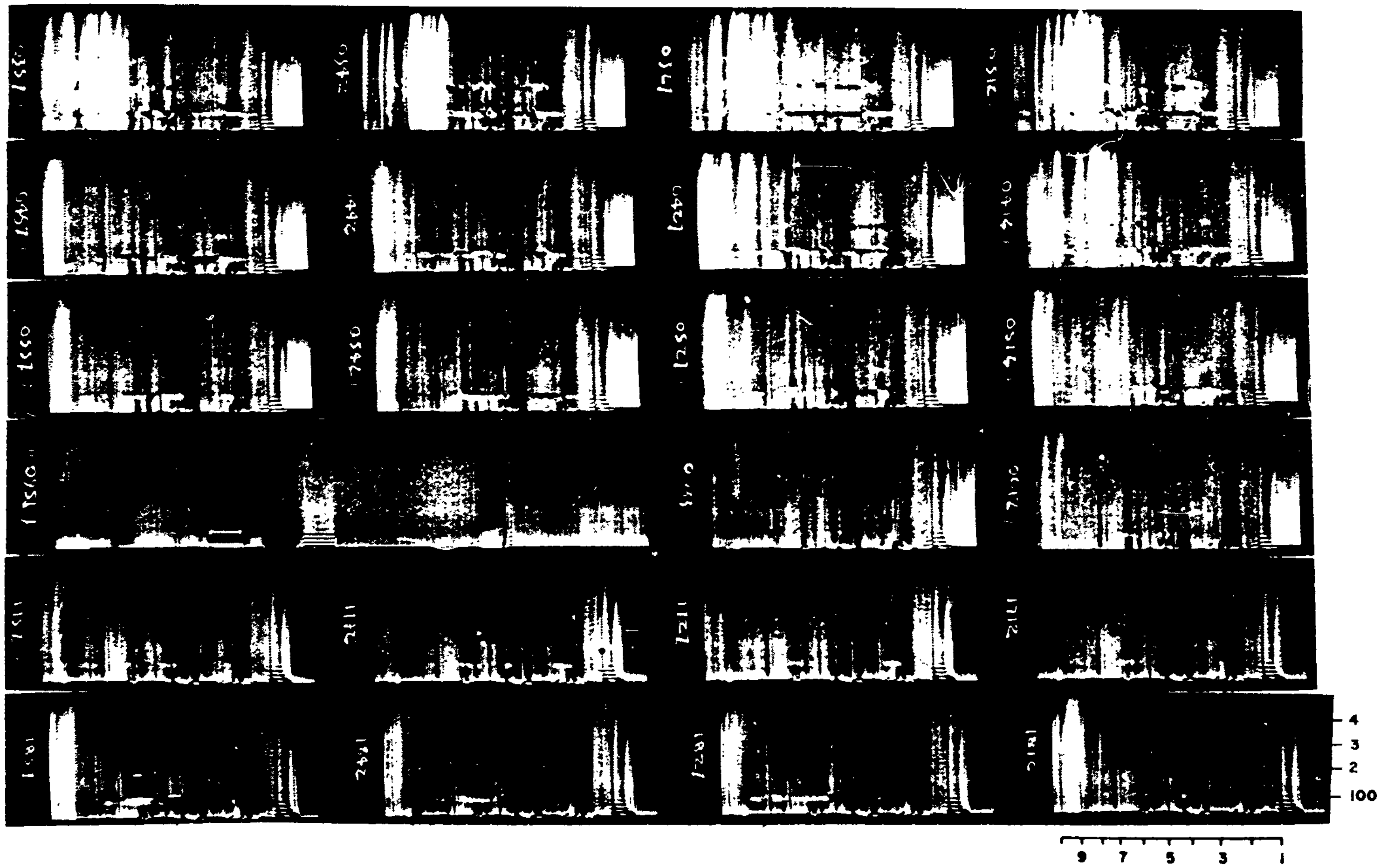


21 JULY 0012-0557

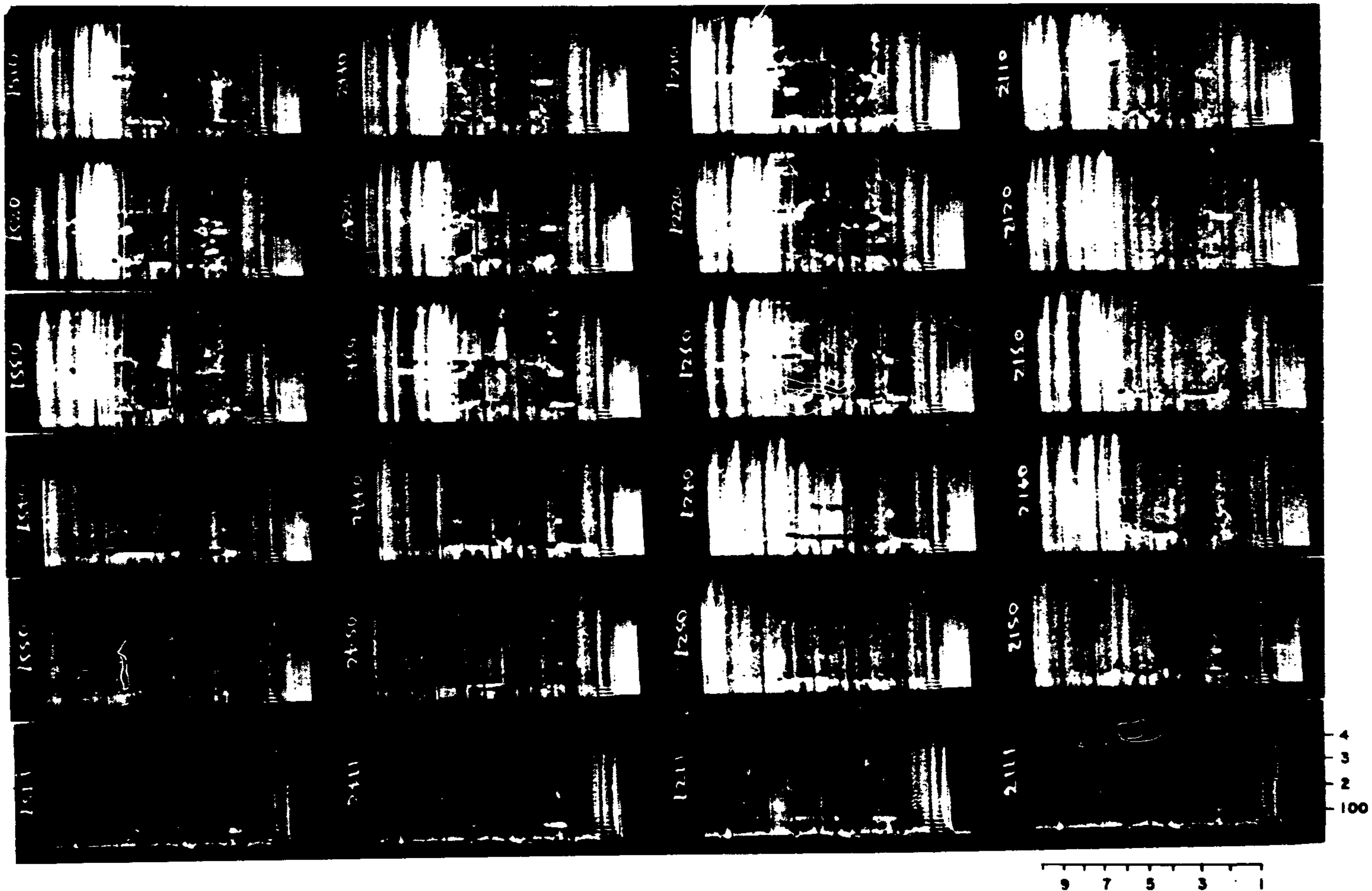
C=0.8



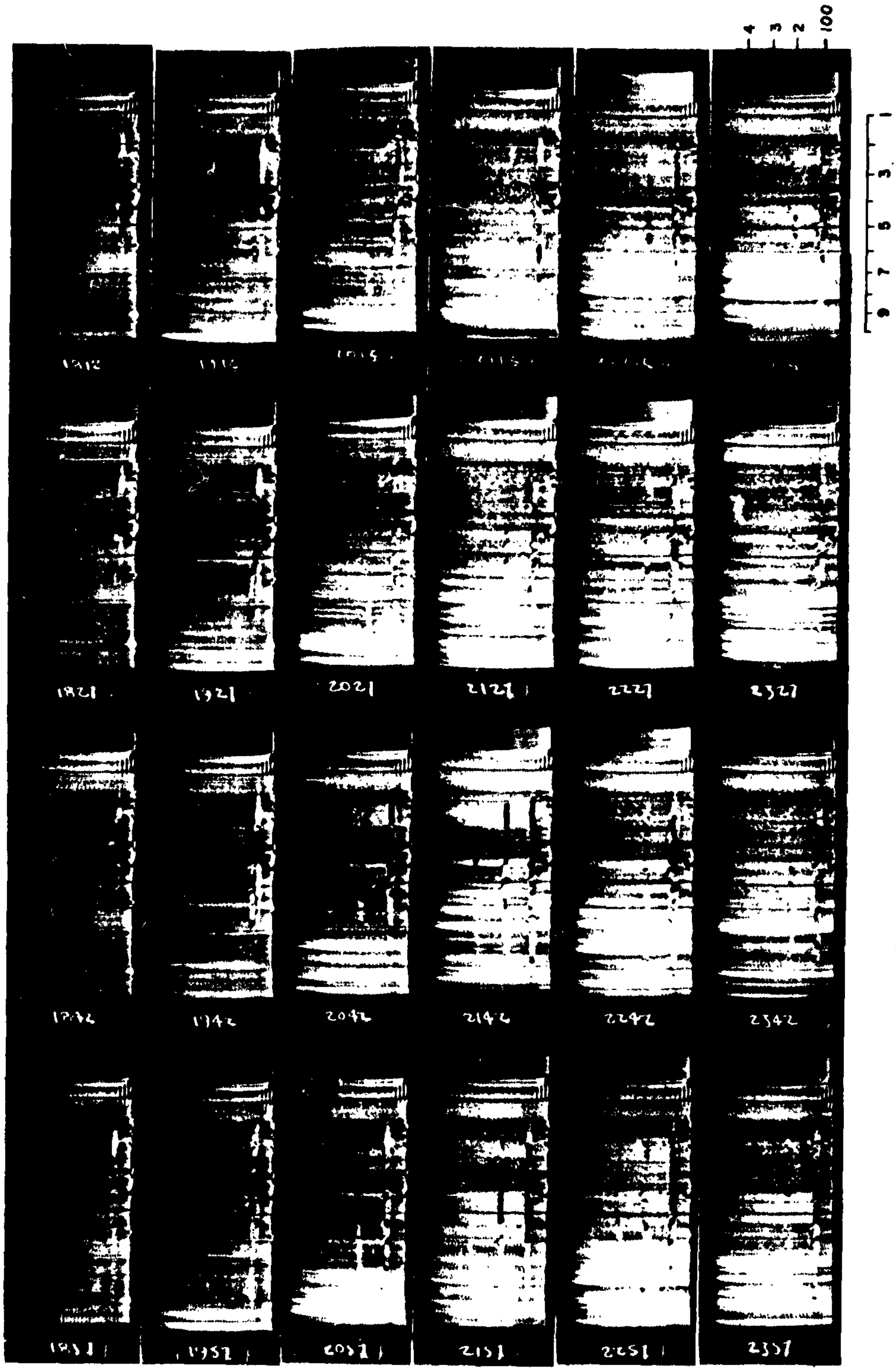
21 JULY 1912 – 2357 C=0.8
22 JULY 0012 – 0057 C=0.4



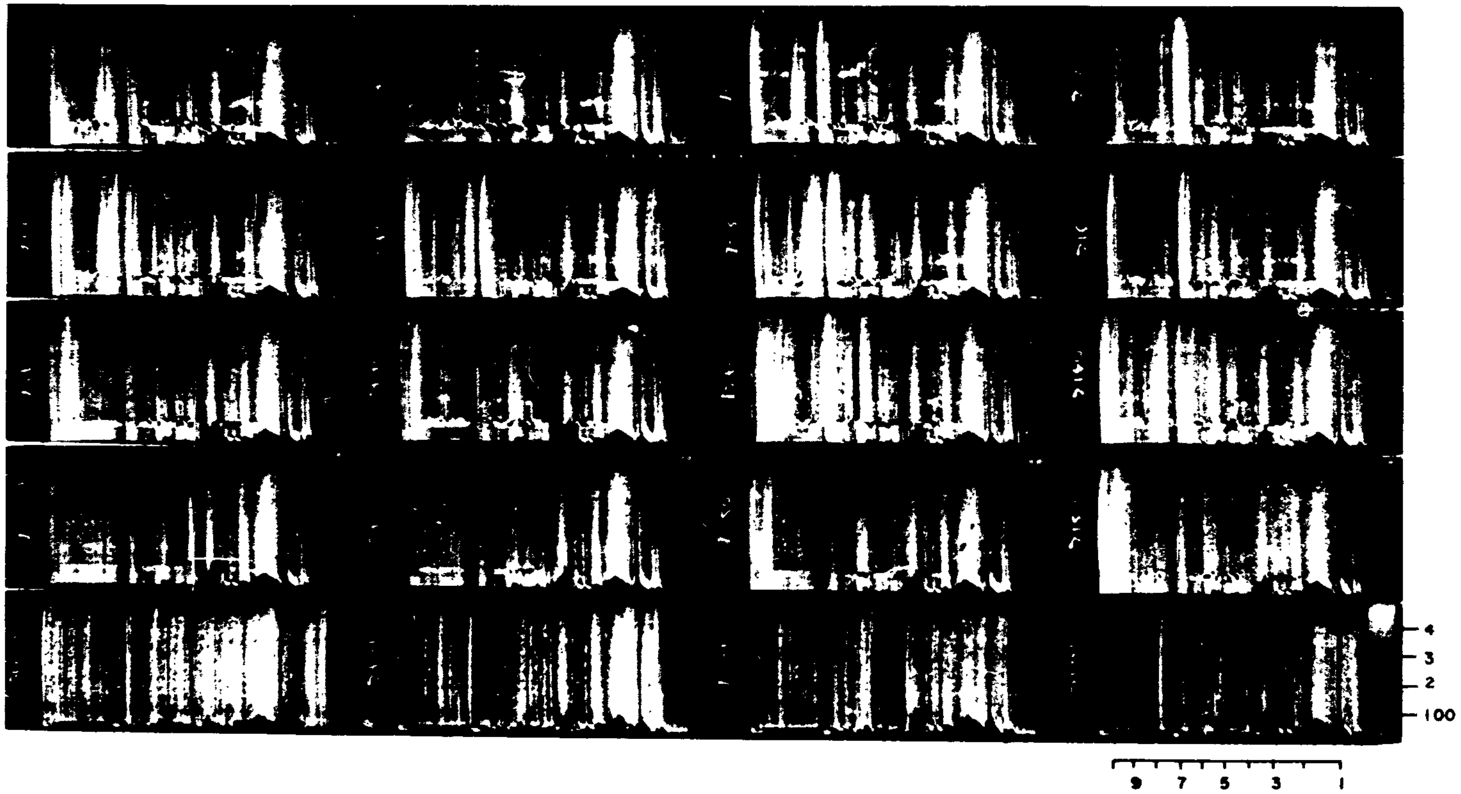
21 JULY 0312 - 0612 C=0.8
21 JULY 0935 - 0951 C=0.8
21 JULY 1712 - 1857 C=0.8



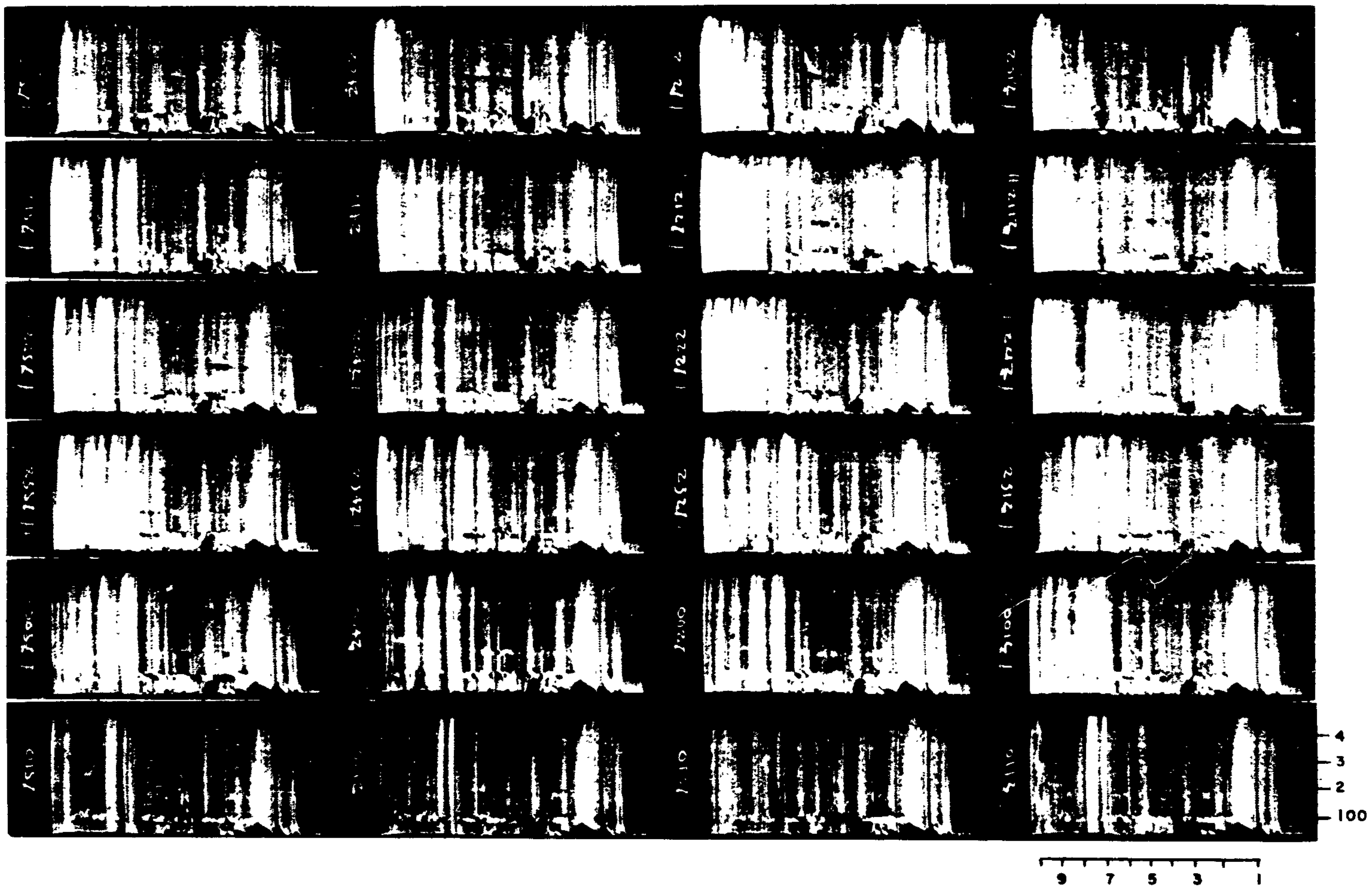
22 JULY 0112 - 0557 C=0.4
22 JULY 1712 - 1757 C=0.4



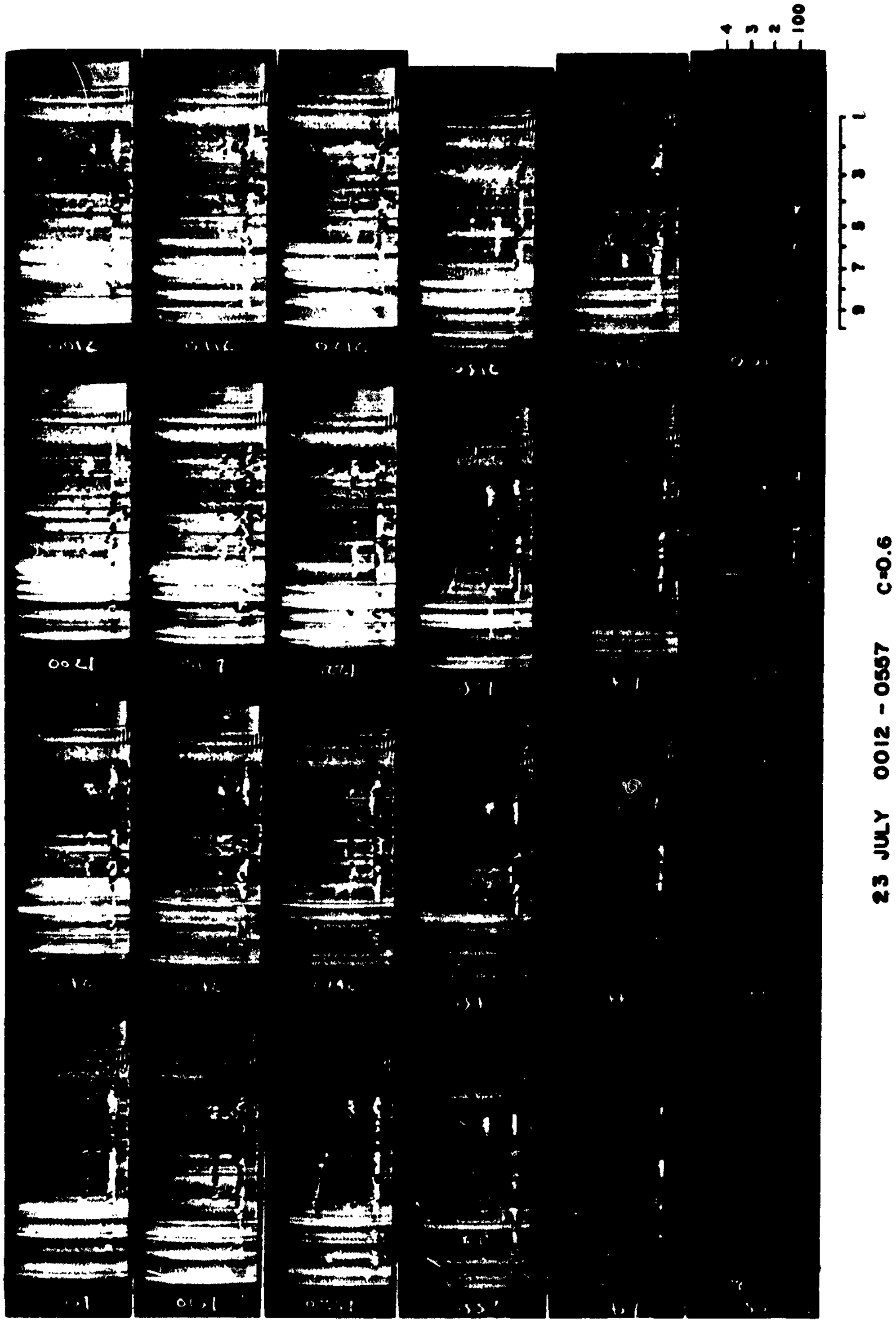
22 JULY 1812 - 2357 C=0.6



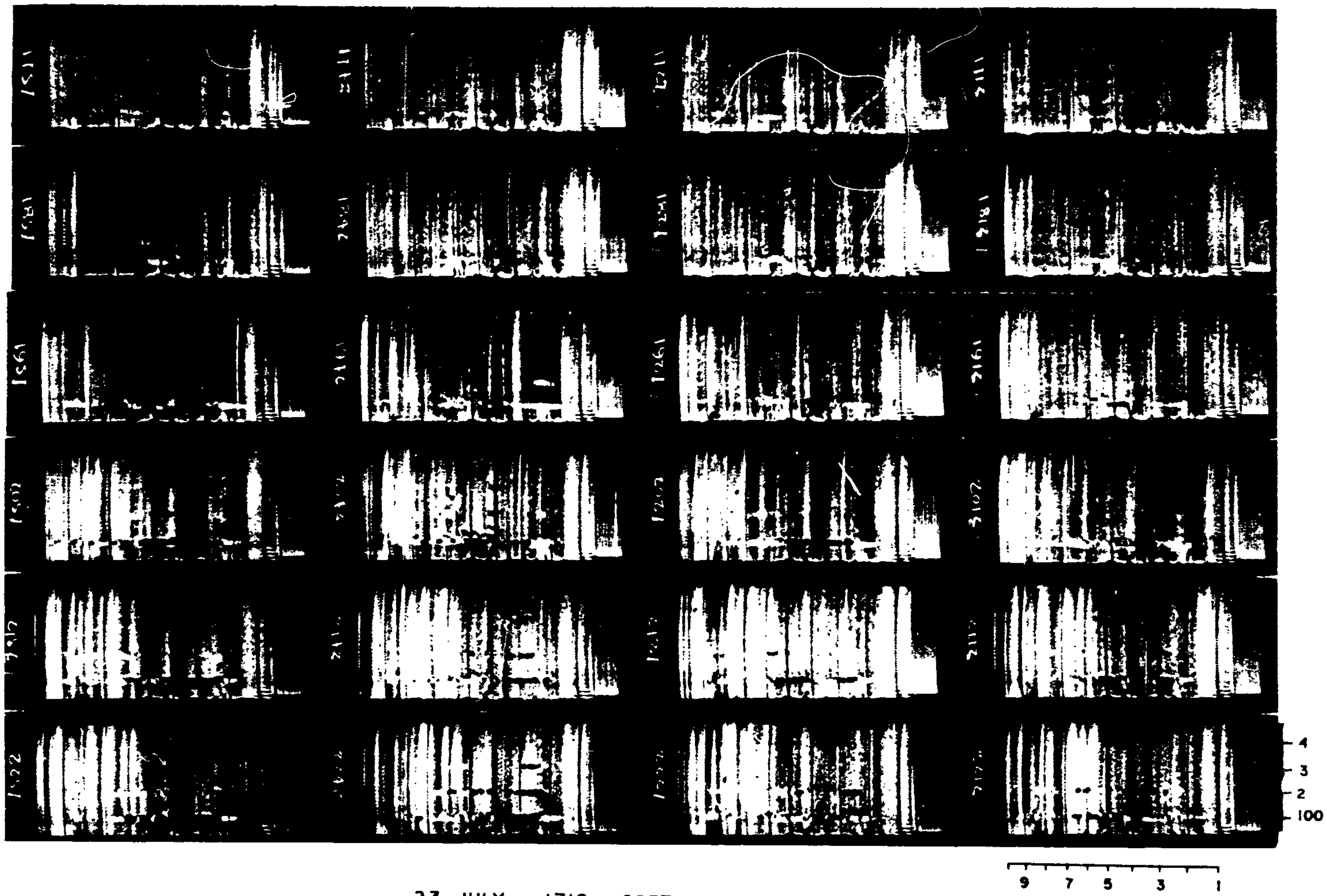
23 JULY 0212-0557 C=0.6
23 JULY 1612-1657 C=0.6



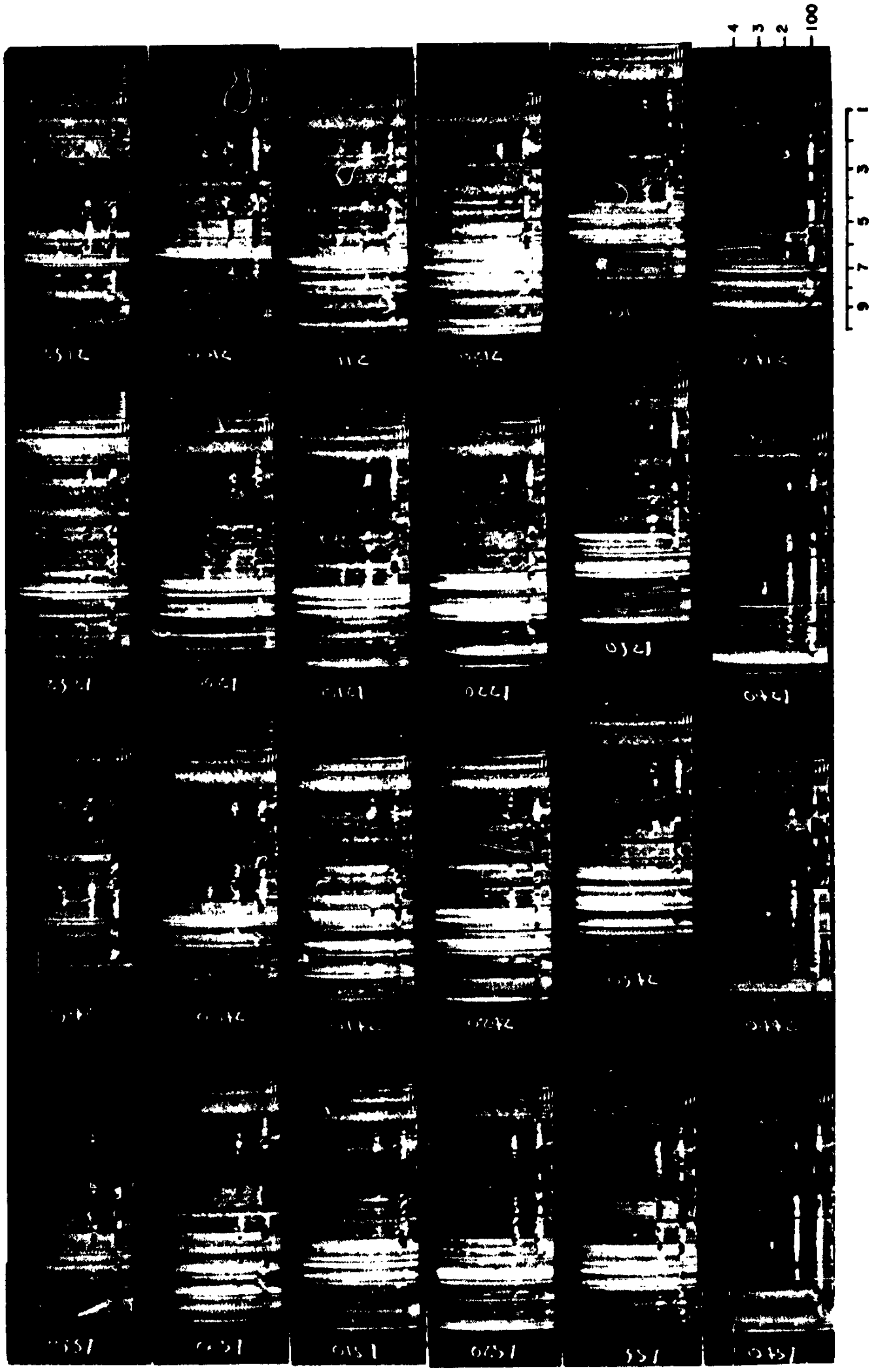
22 JULY 2012–2357 C=0.4
23 JULY 0012–0157 C=0.6



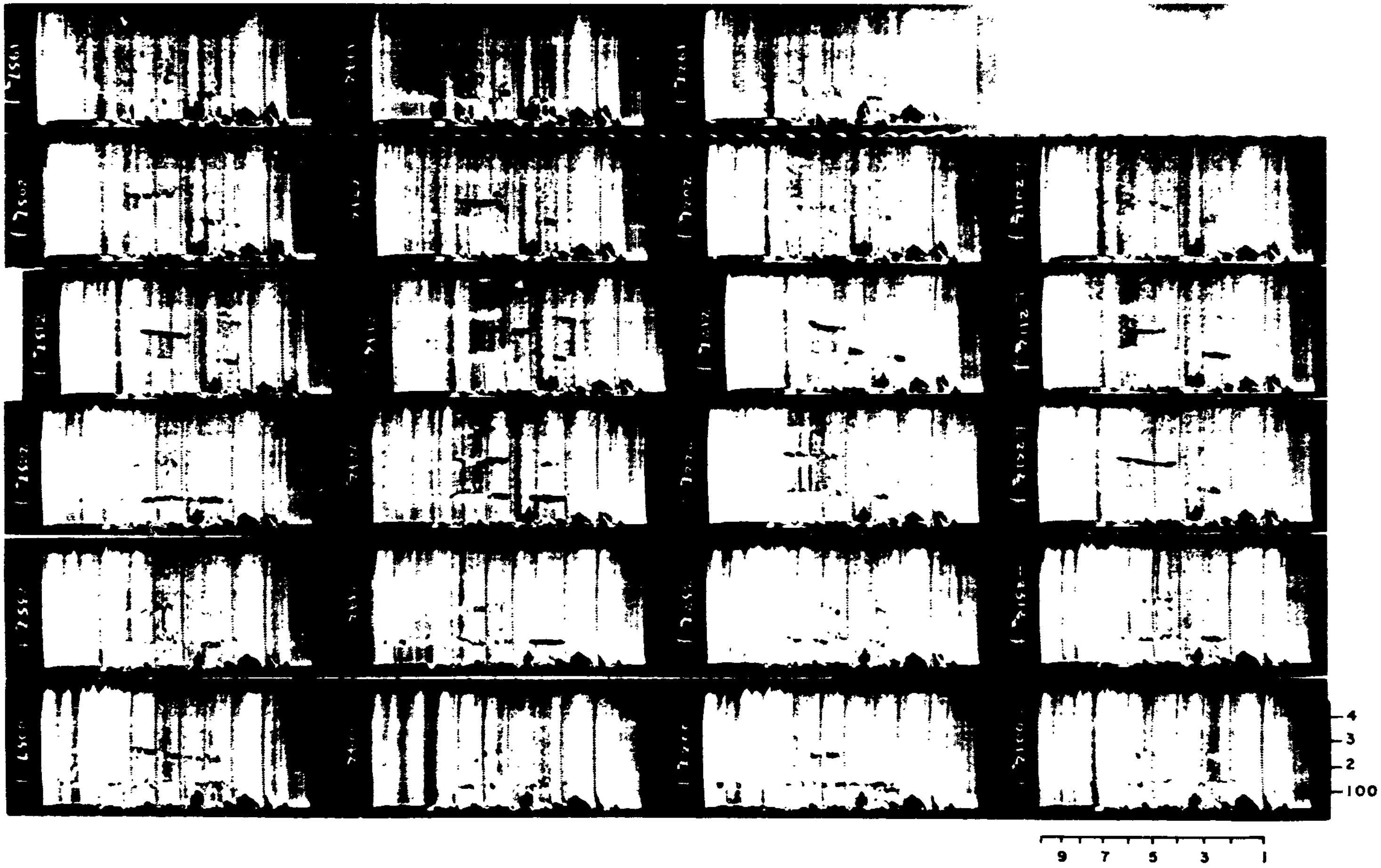
23 JULY 0012 - 0557 C=0.6



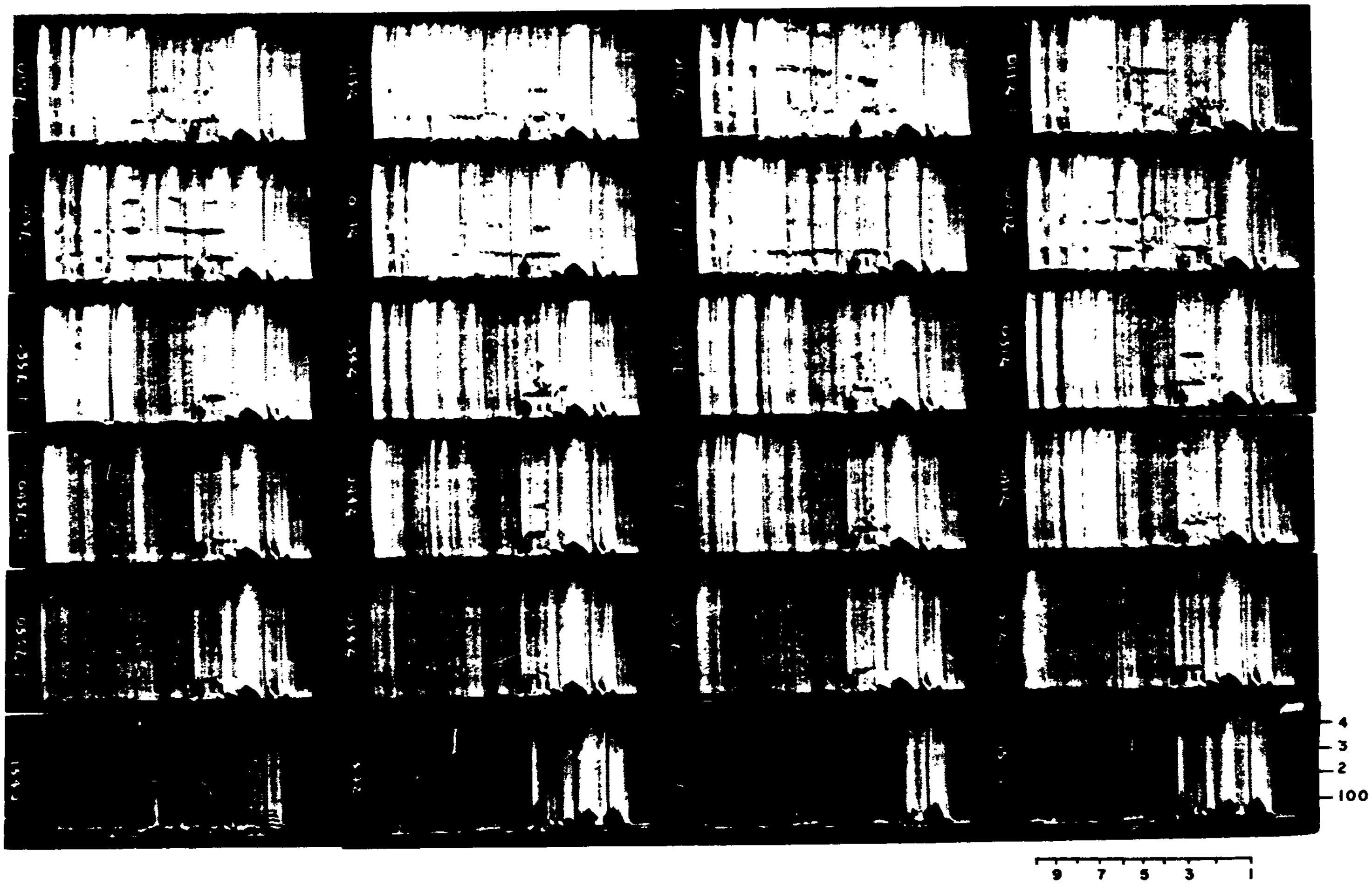
23 JULY 1712 – 2257 C=0.6



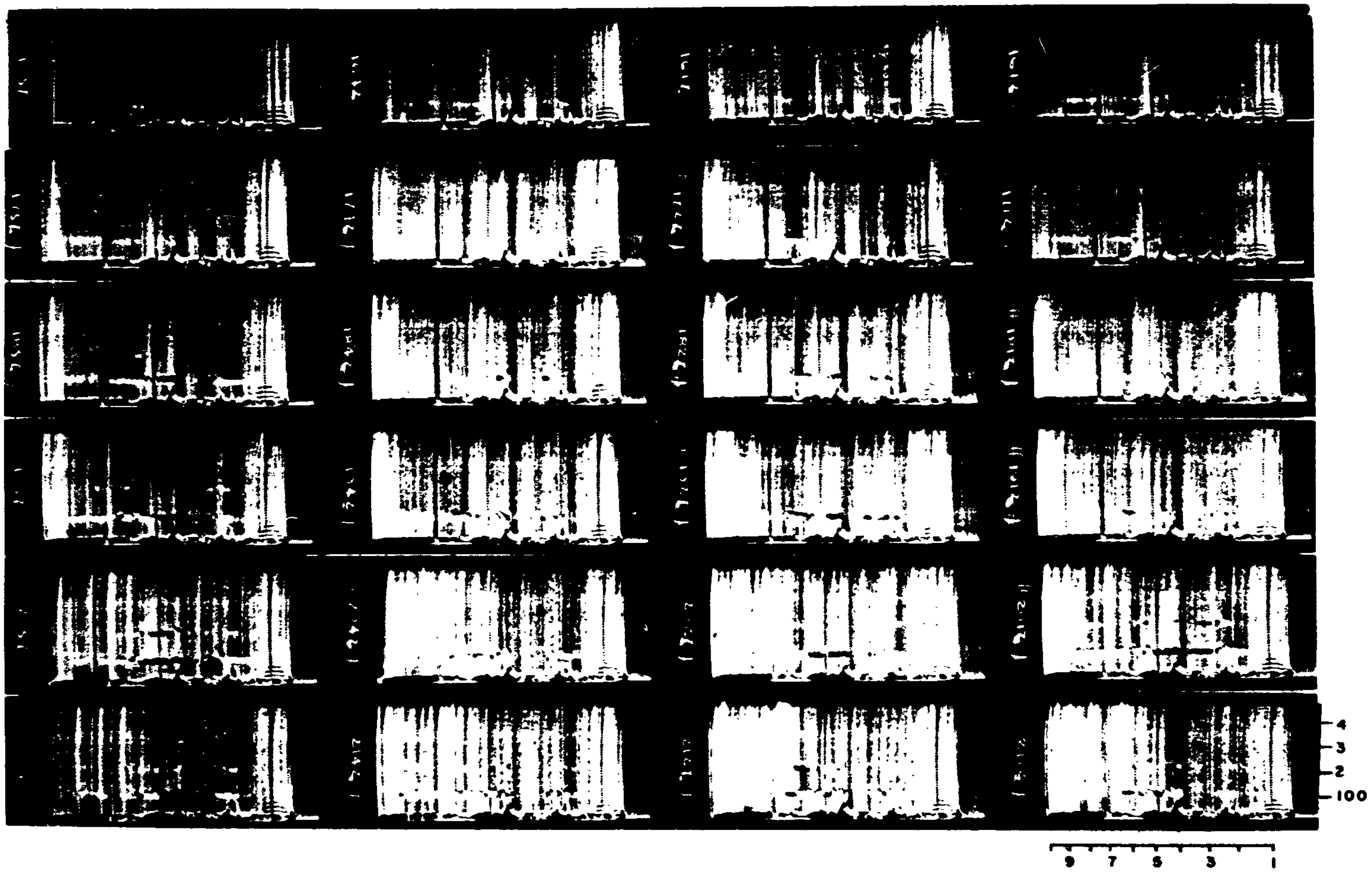
23 JULY 2312 – 2357 C=0.6



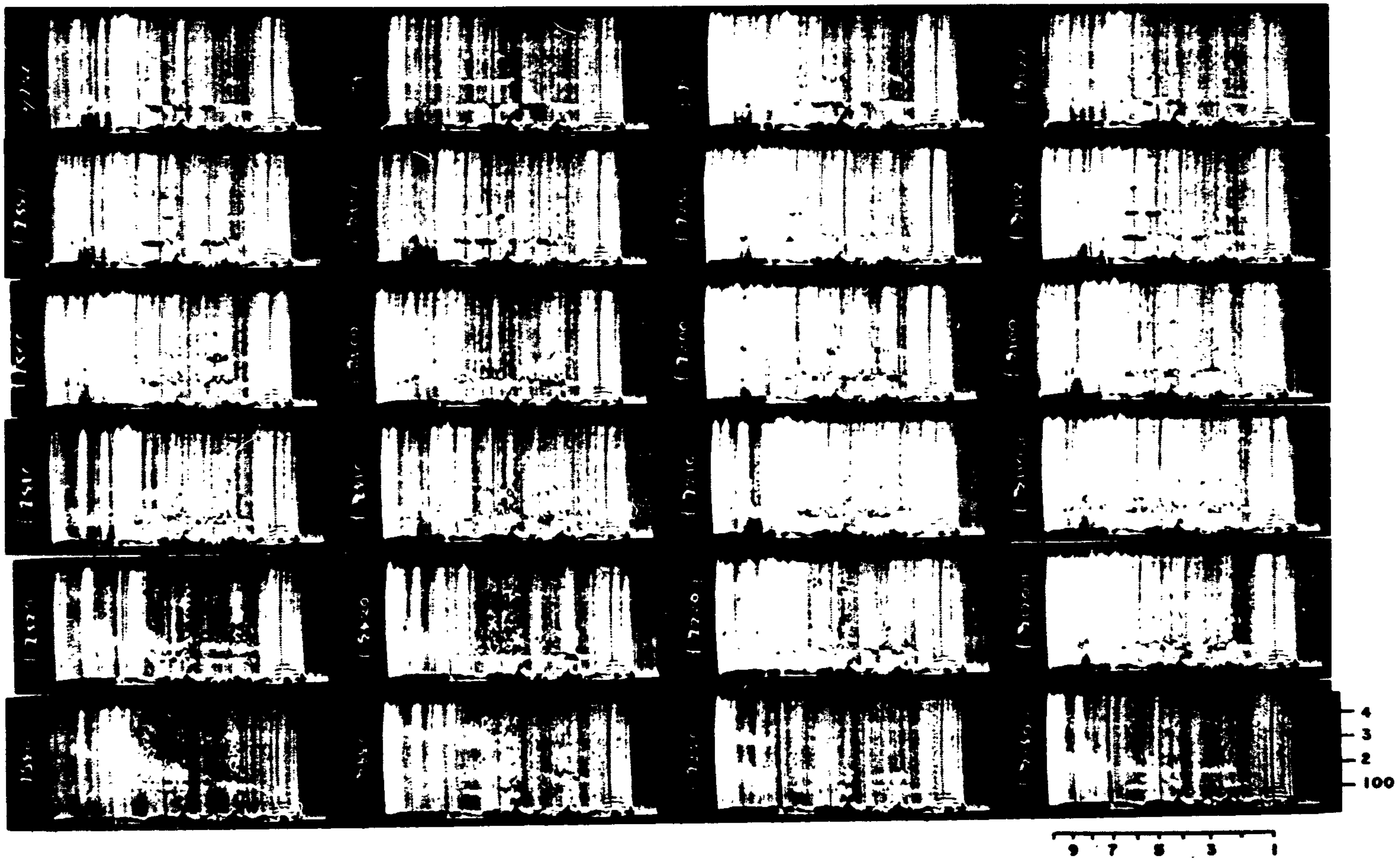
24 JULY 1912-2357 C=1.0
25 JULY 0012-0057 C=1.0



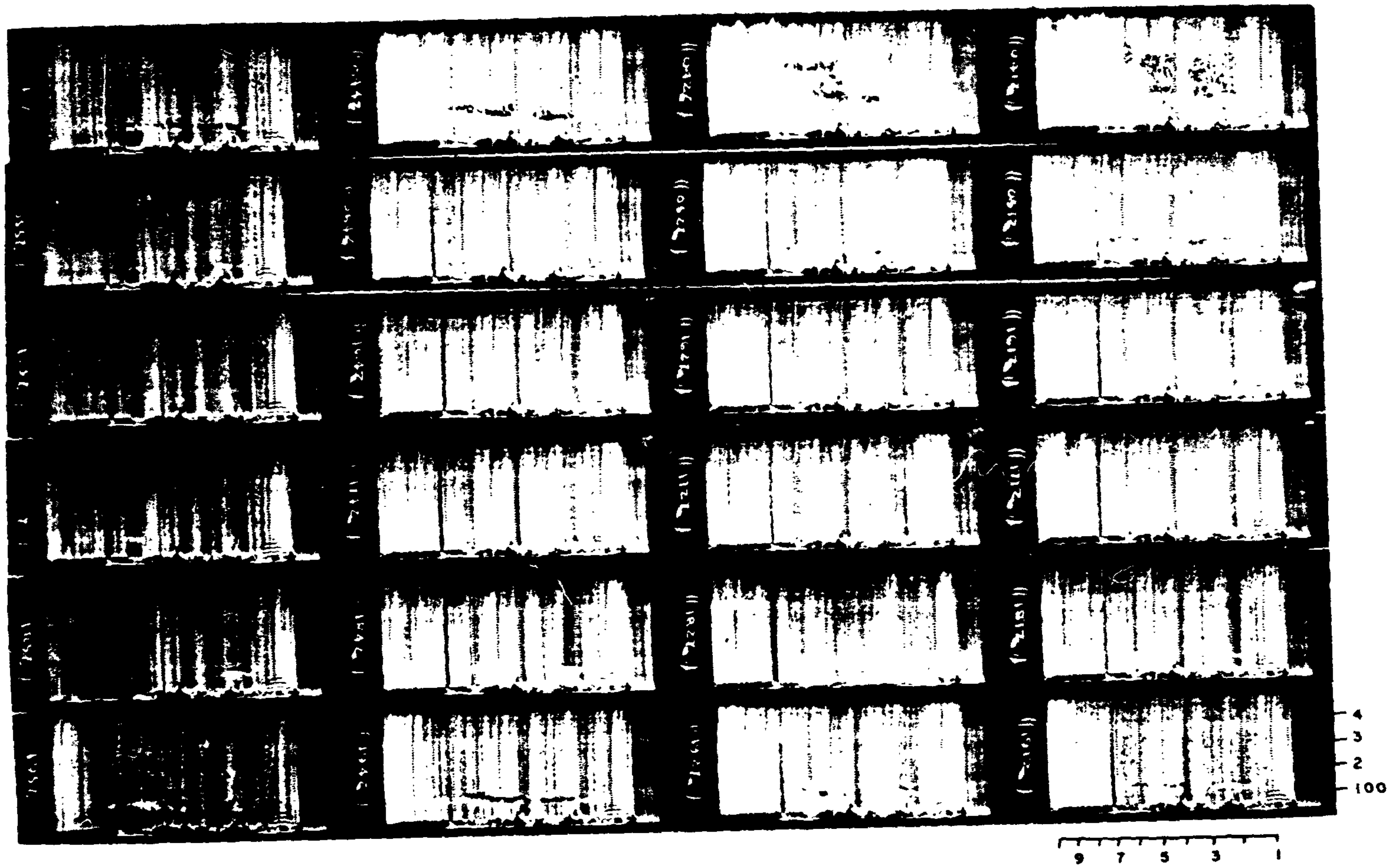
25 JULY 0112-0557 C=1.0
25 JULY 1525-1540 C=1.0



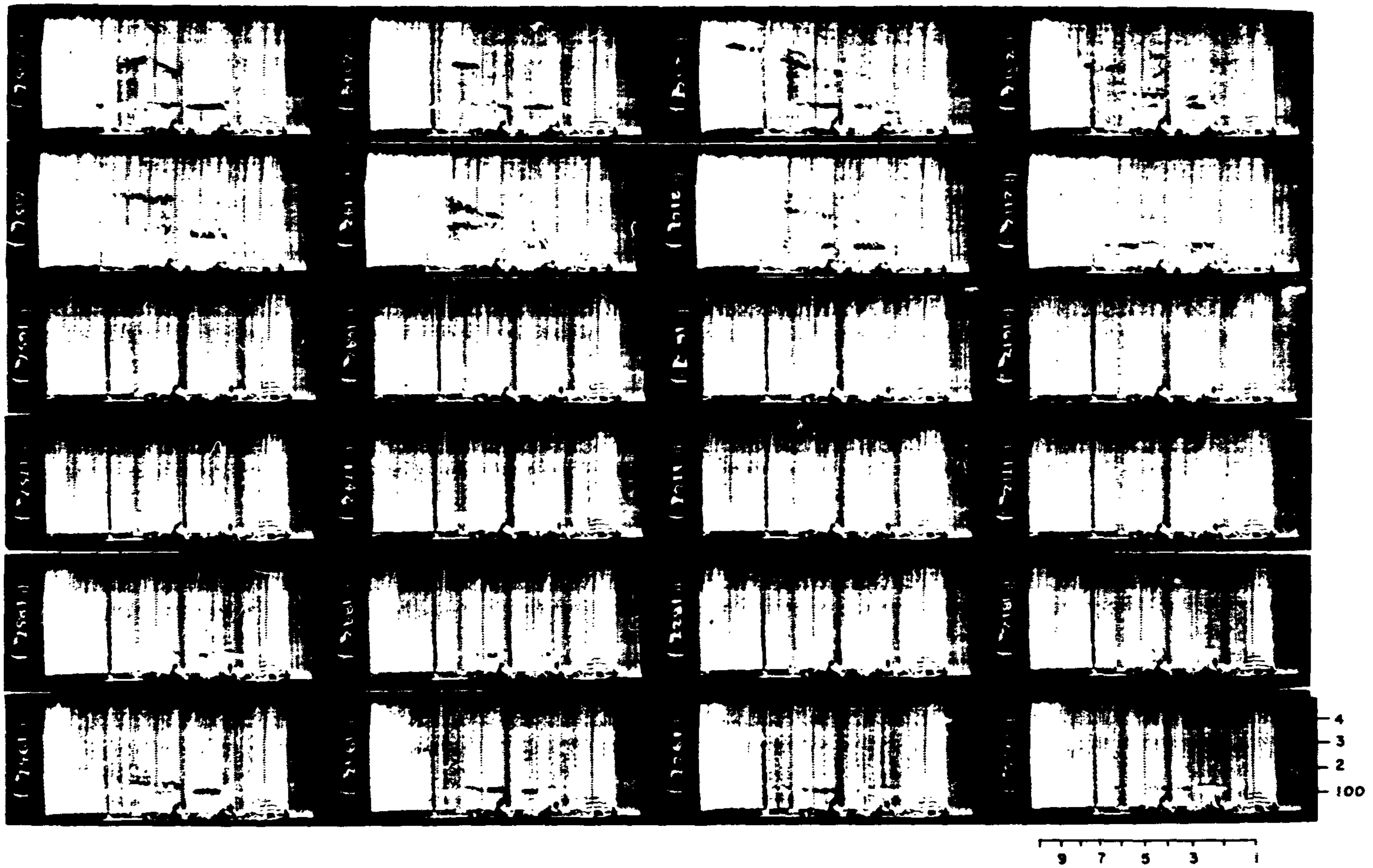
25 JULY 1612-2157 C=1.0



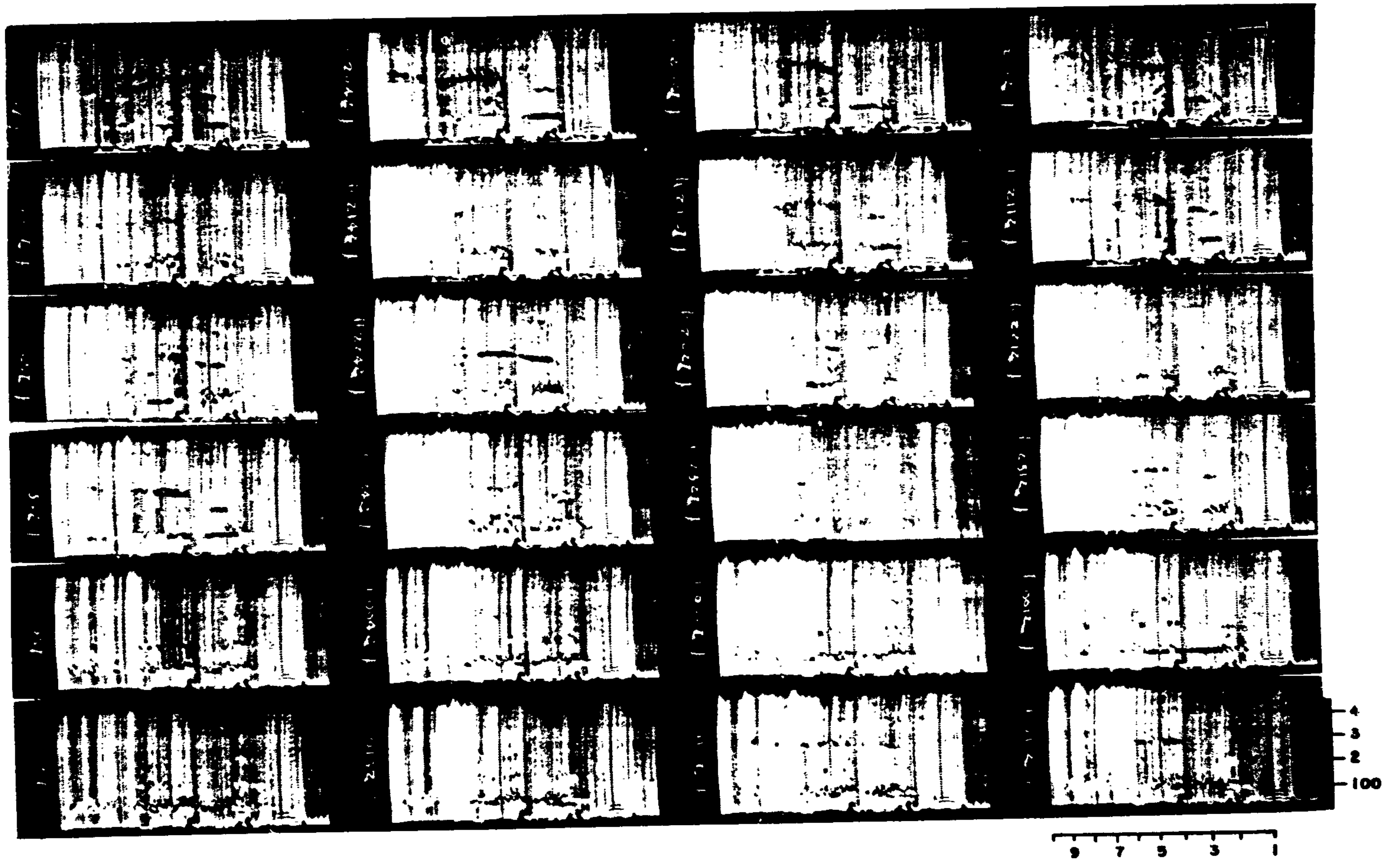
25 JULY 2212–2357 C=1.0
26 JULY 0012–0357 C=1.6



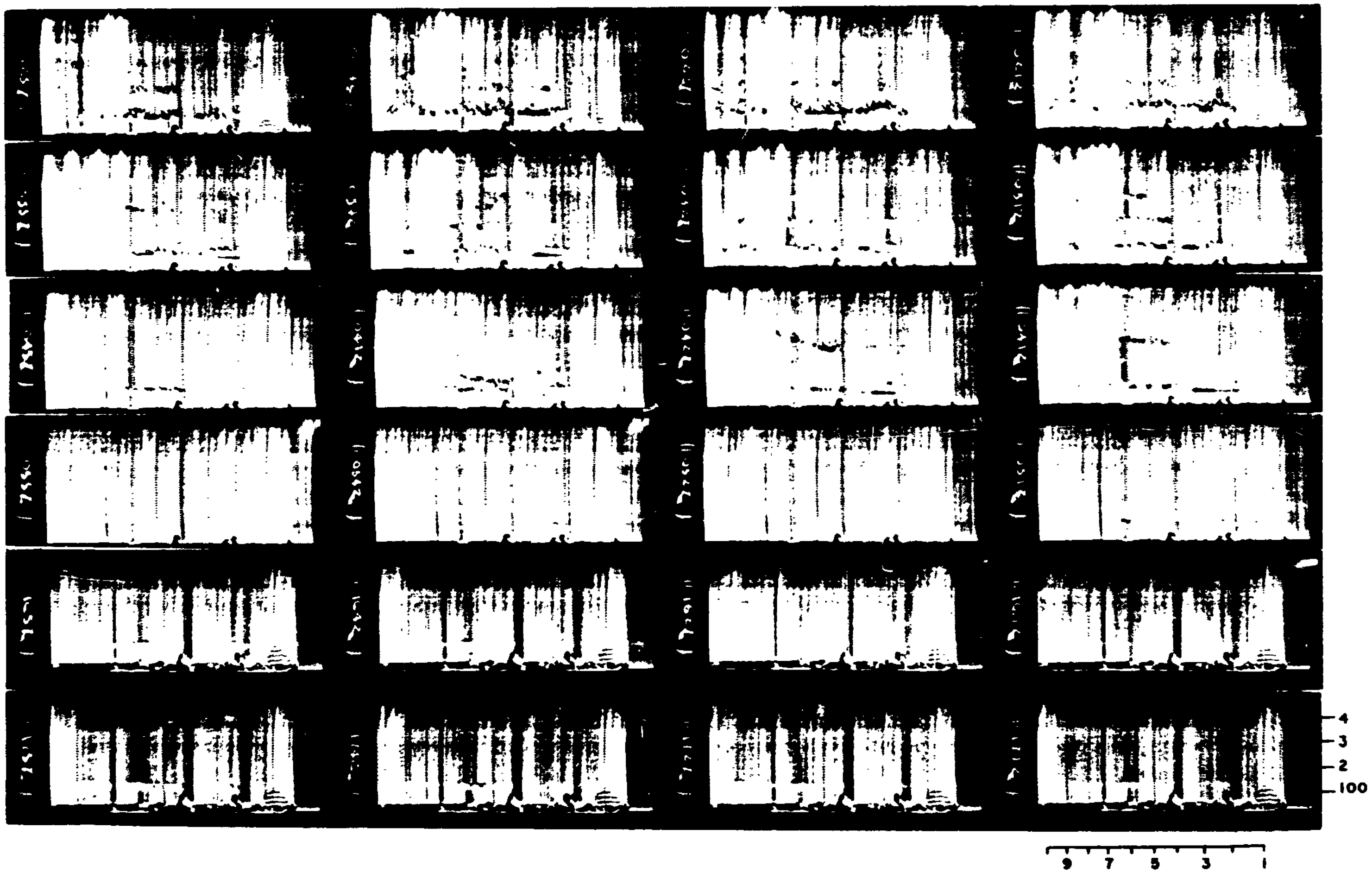
26 JULY 0412–0557 C=1.6
26 JULY 1612–1957 C=1.6



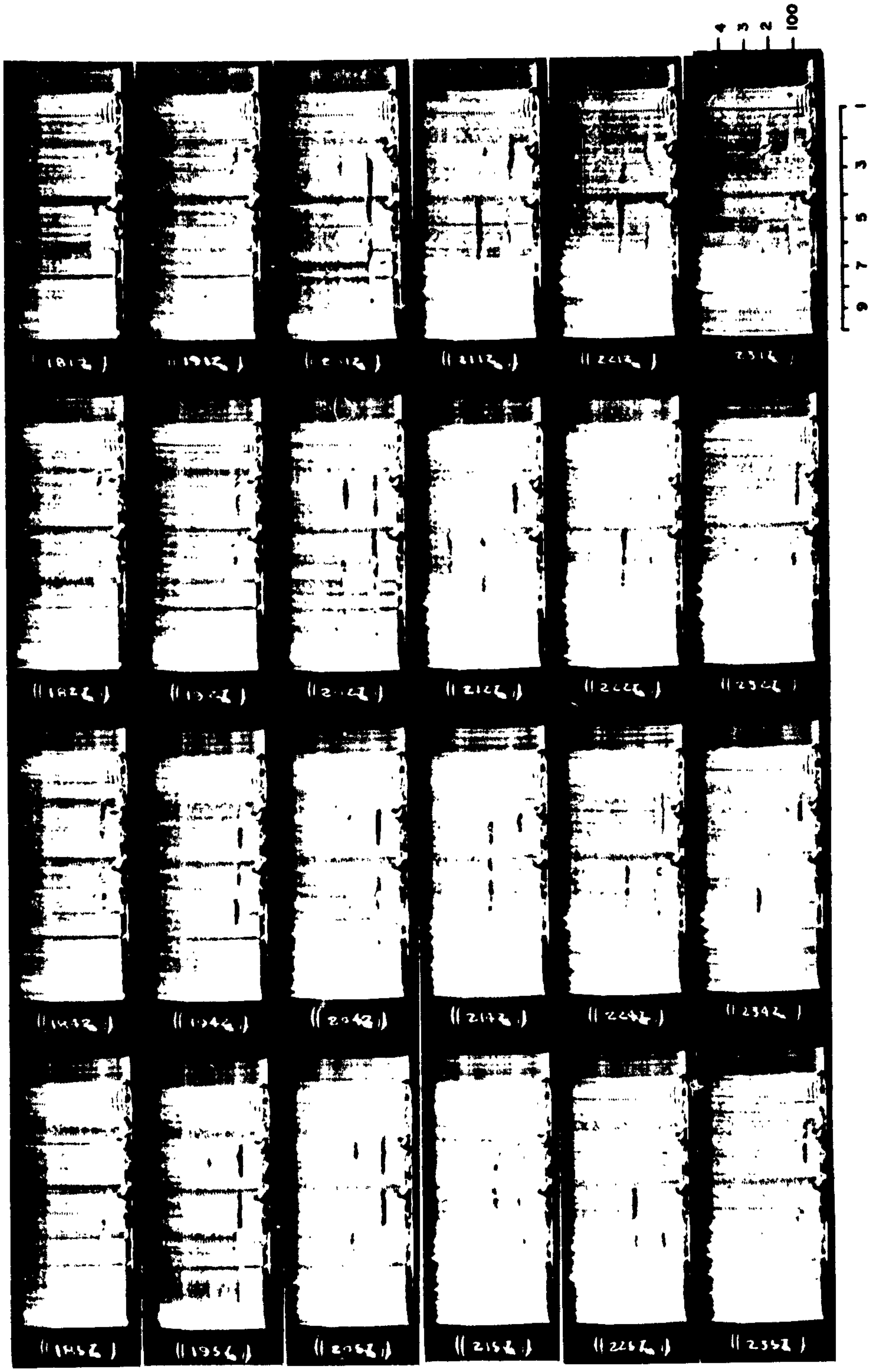
26 JULY 2012-2157 C=1.6
27 JULY 1612-1957 C=1.4



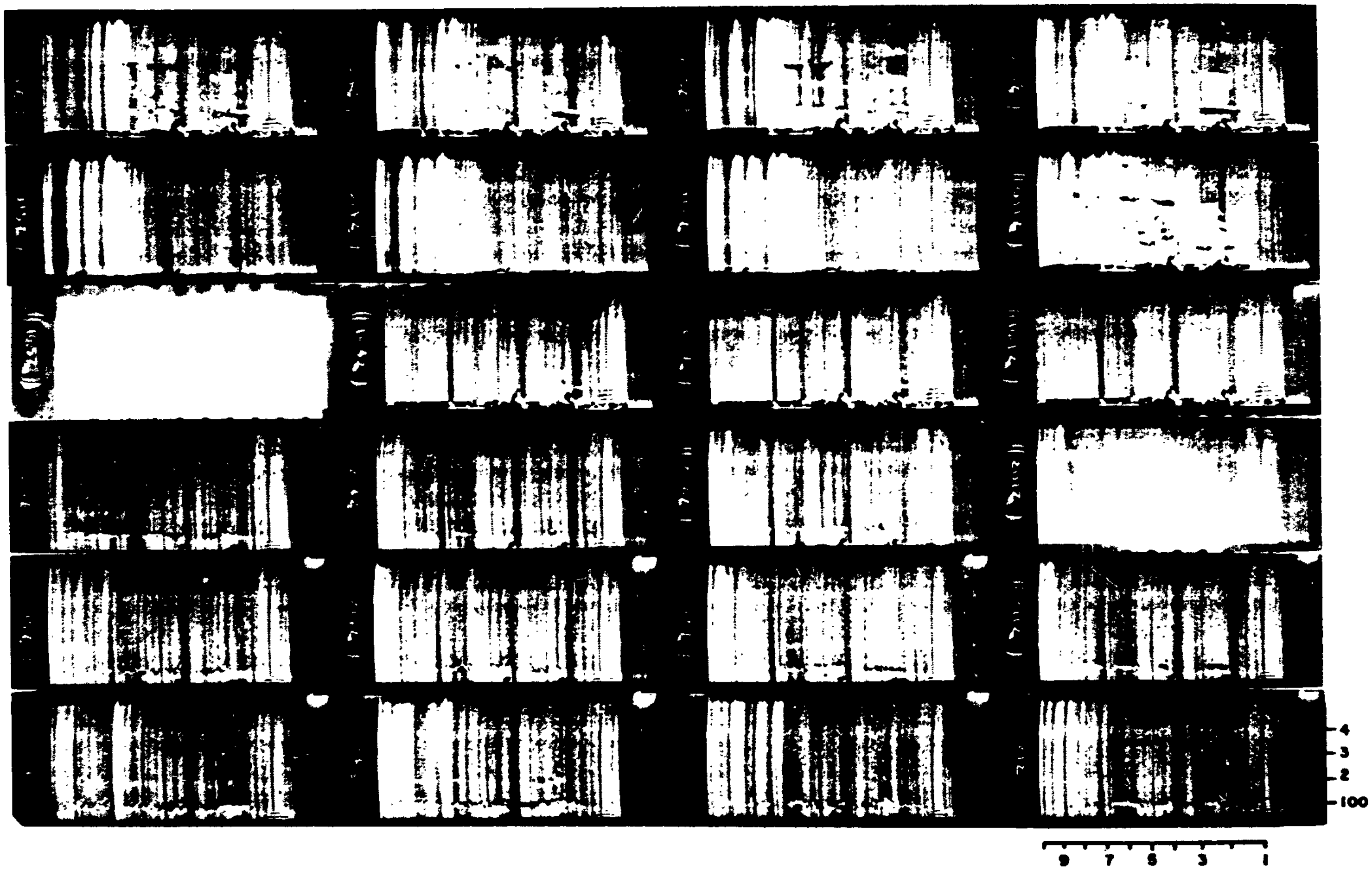
27 JULY 2012–2357 C=1.4
28 JULY 0012–0157 C=1.1



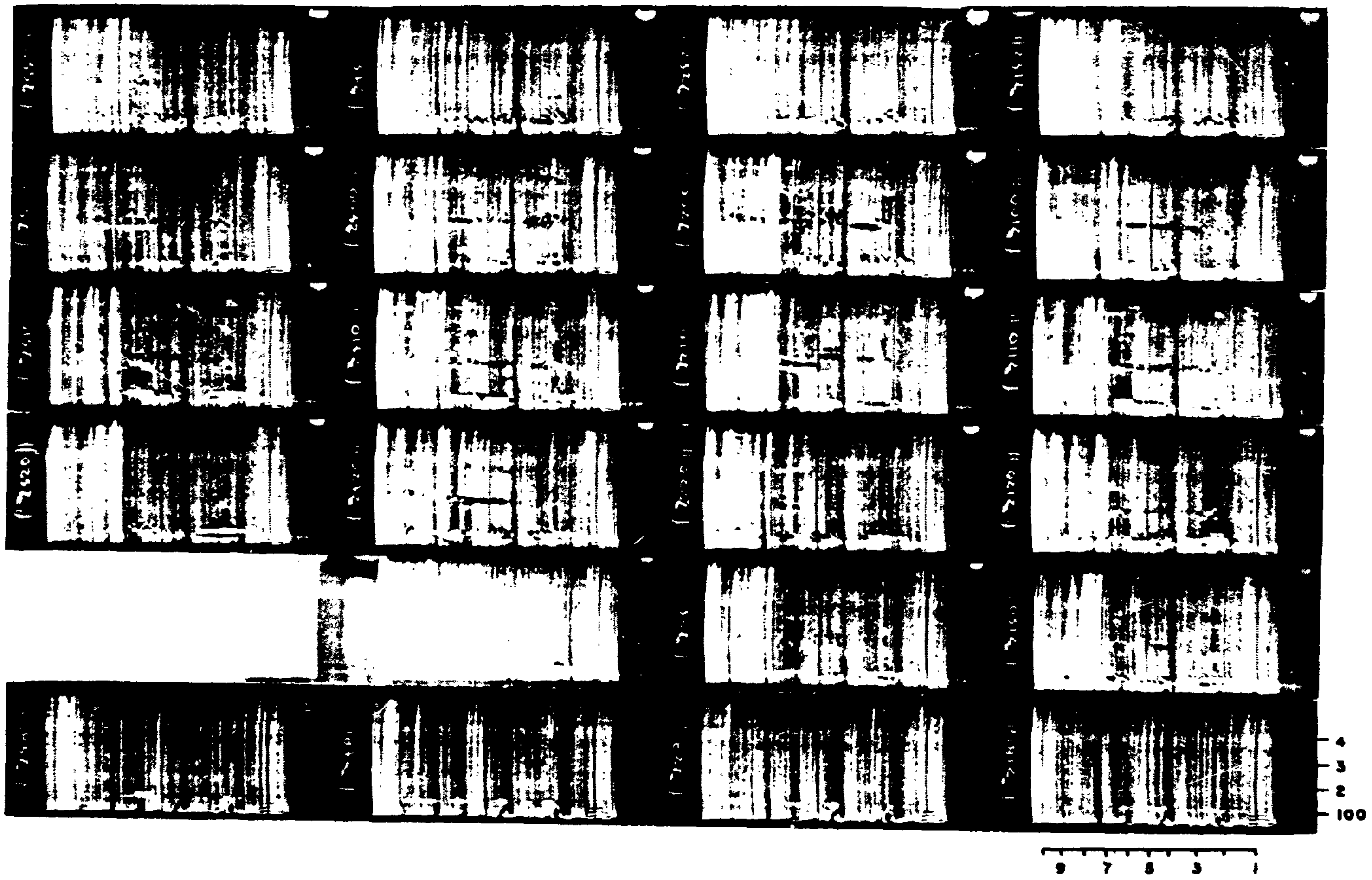
28 JULY 0212-0557 C=1.1
28 JULY 1612-1757 C=1.1



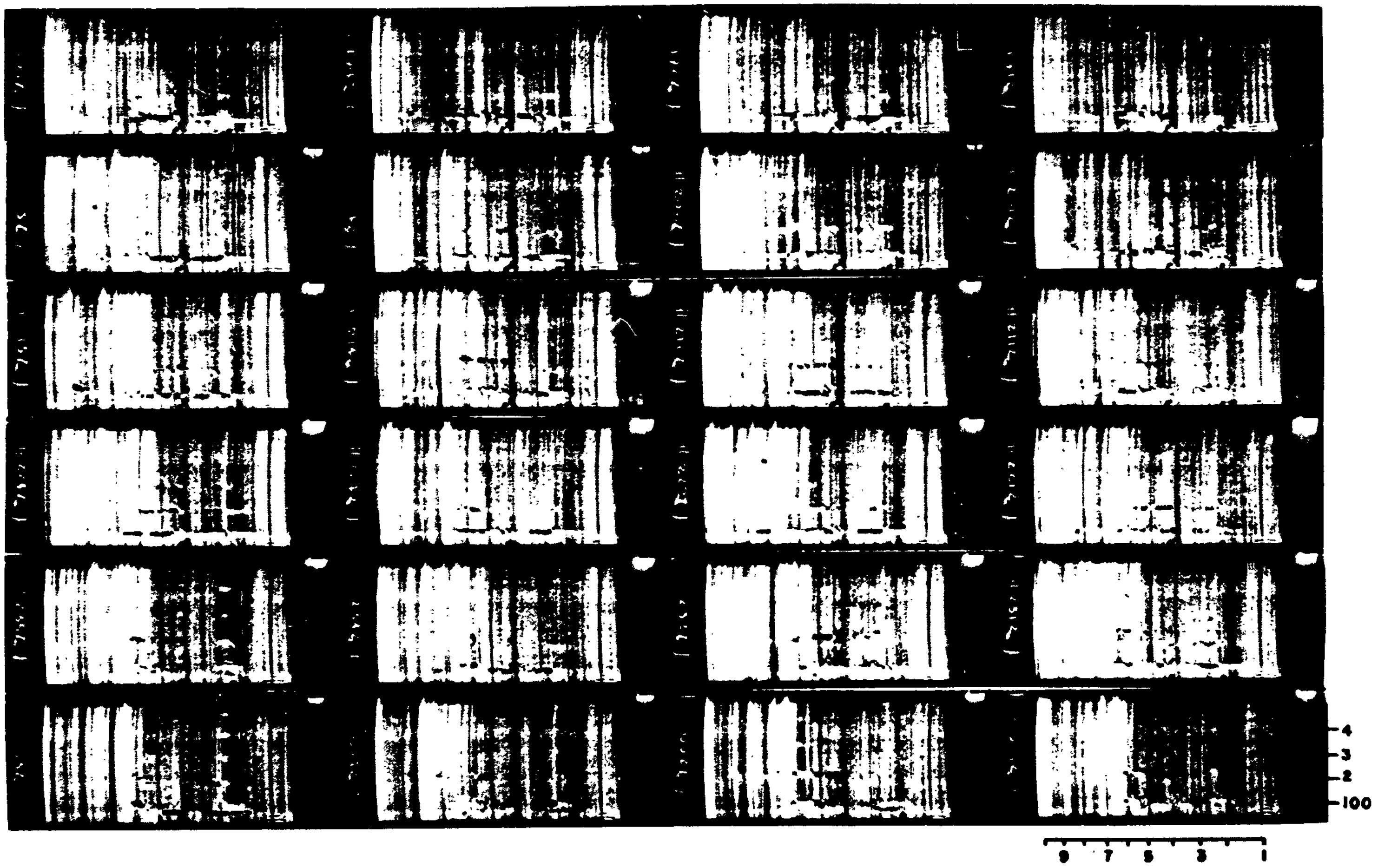
28 JULY 1812-2357 C=1.1



29 JULY 0012-0157 C=0.7
29 JULY 1612-1657 C=0.7
29 JULY 2012-2257 C=0.7



29 JULY 2312 – 2357 C=1.0
30 JULY 0012 – 0342 C=0.2
30 JULY 0612 – 0657 C=0.2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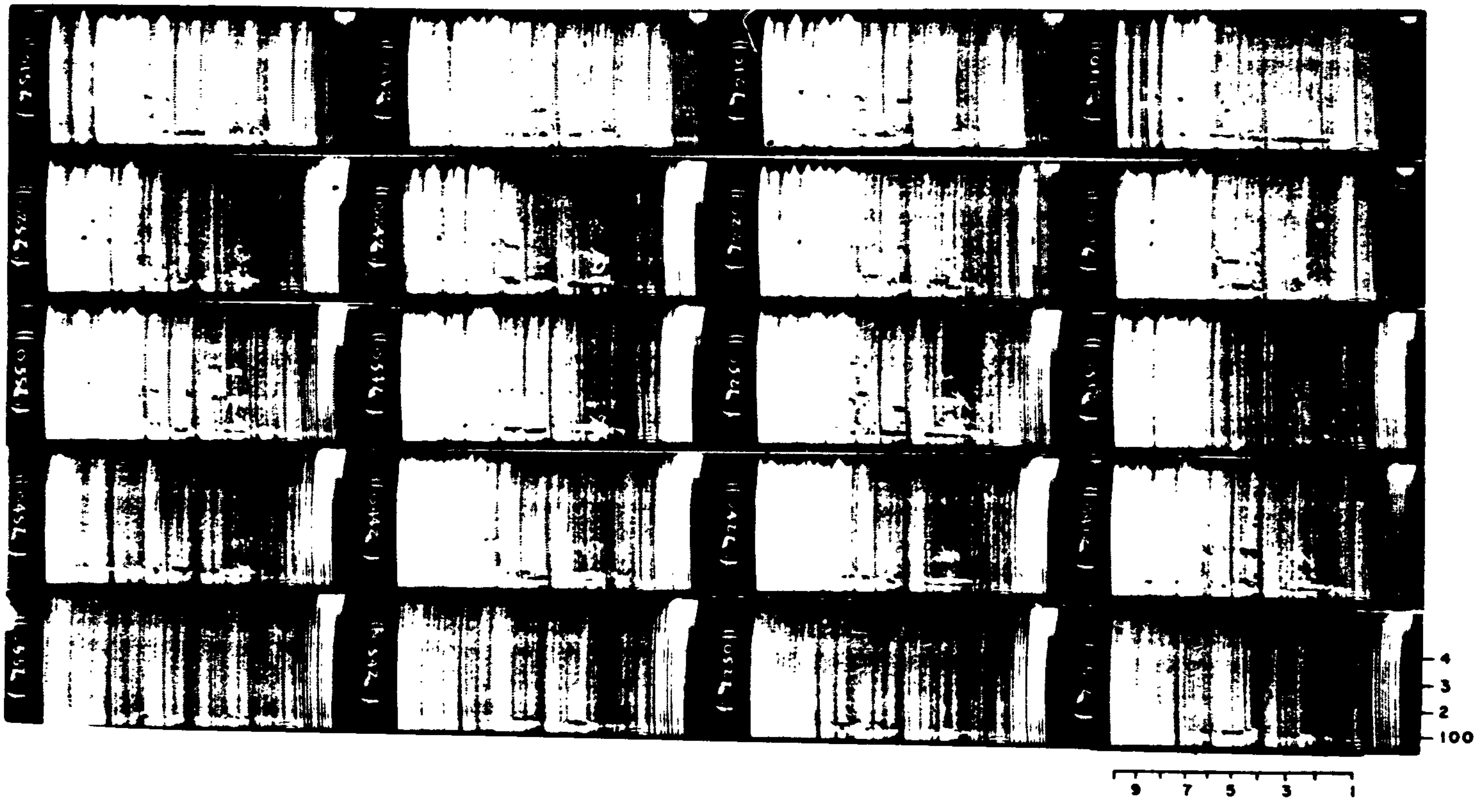
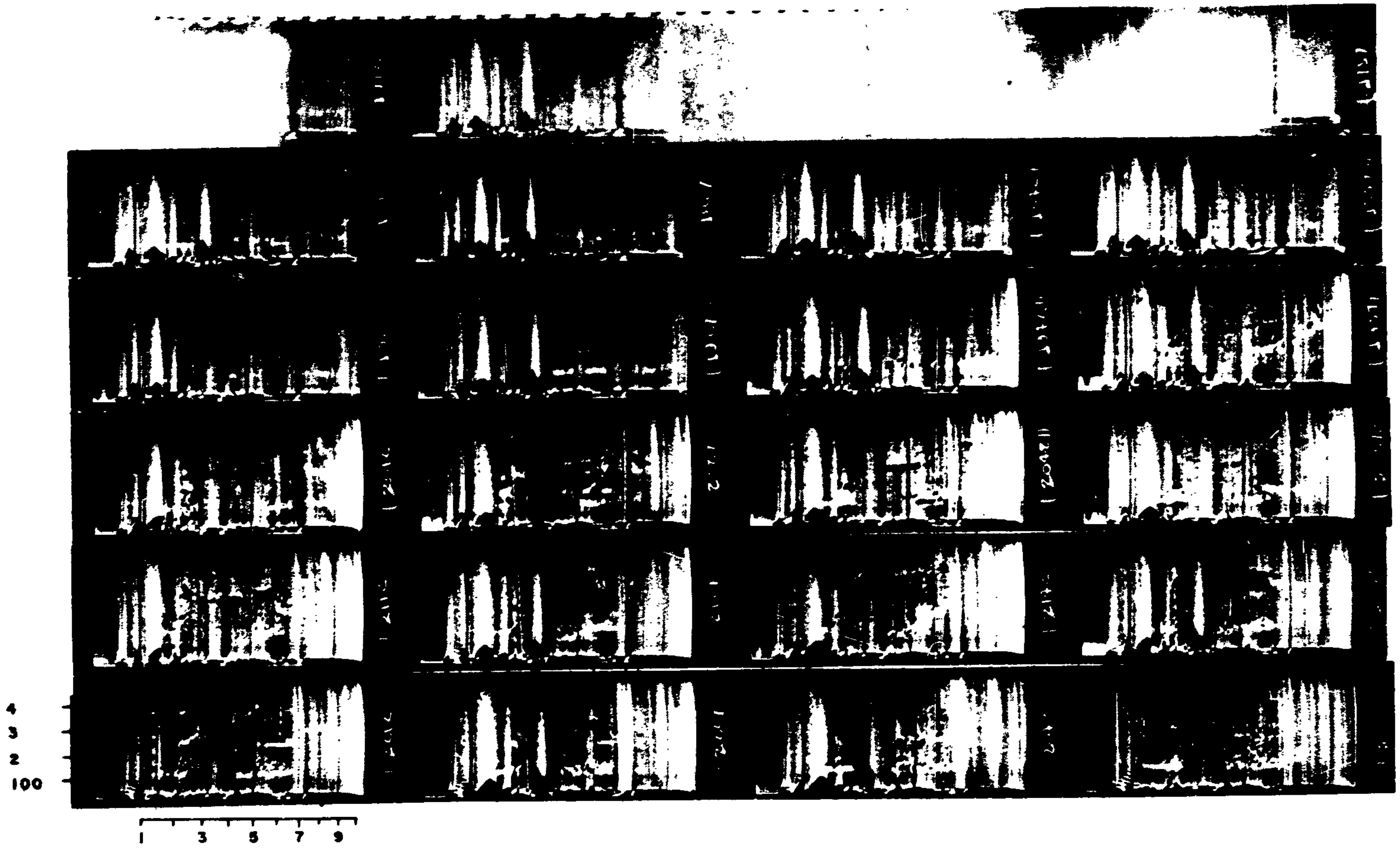
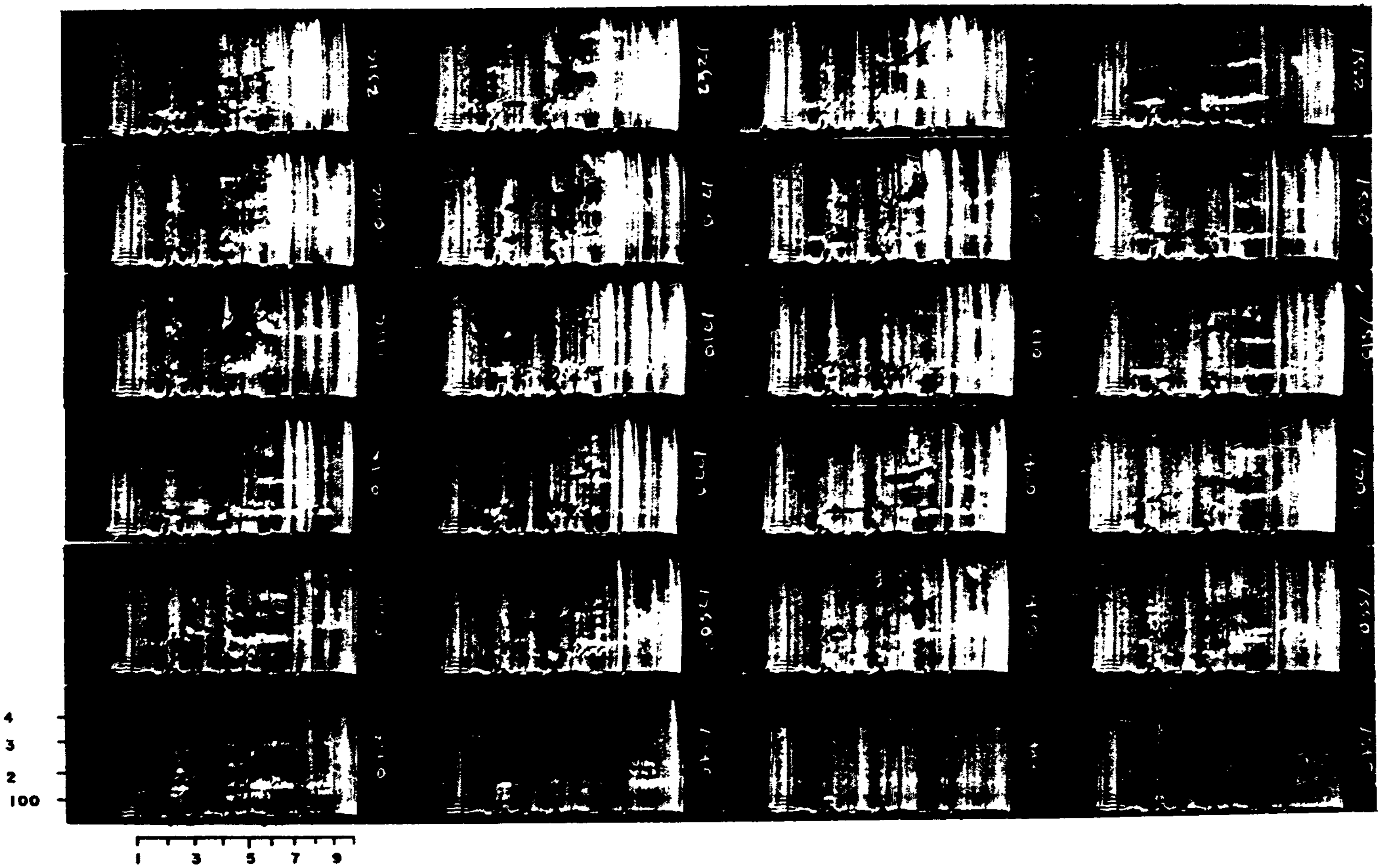
30 JULY 1912-2357 C=0.2
31 JULY 0012-0057 C=0.9



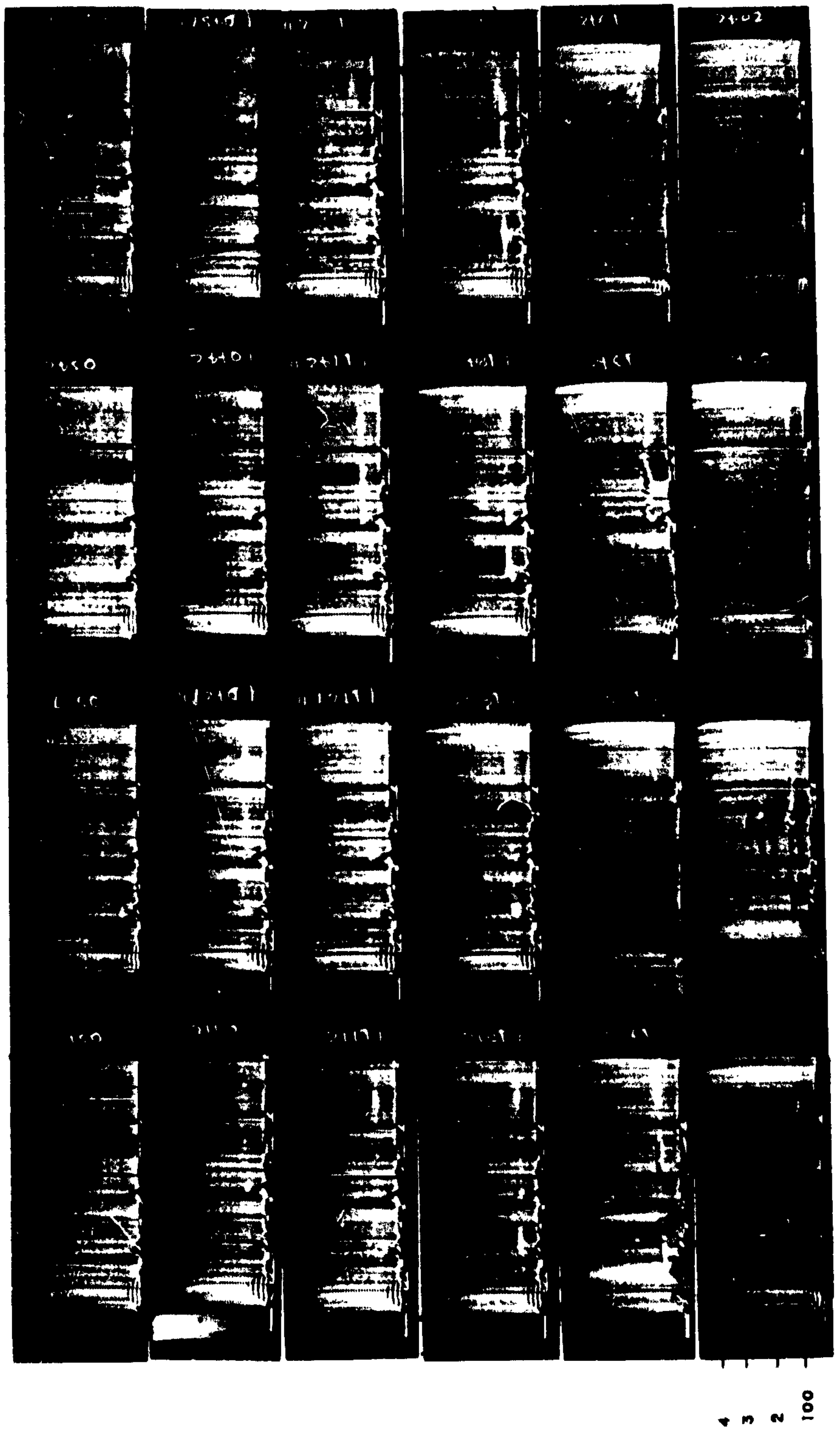
31 JULY 0112-0557 C=0.9



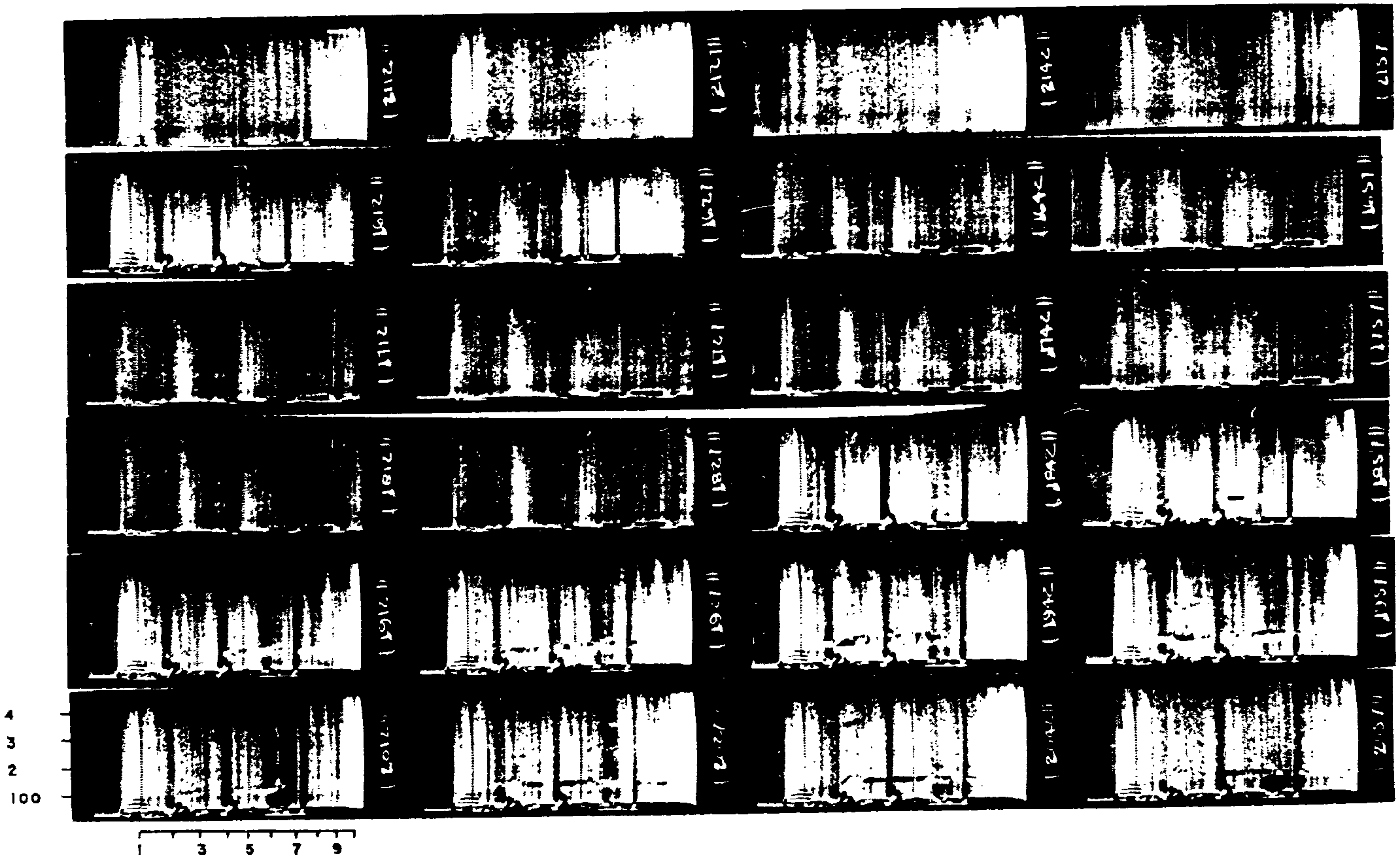
31 JULY 1712 – 2257 C=0.9



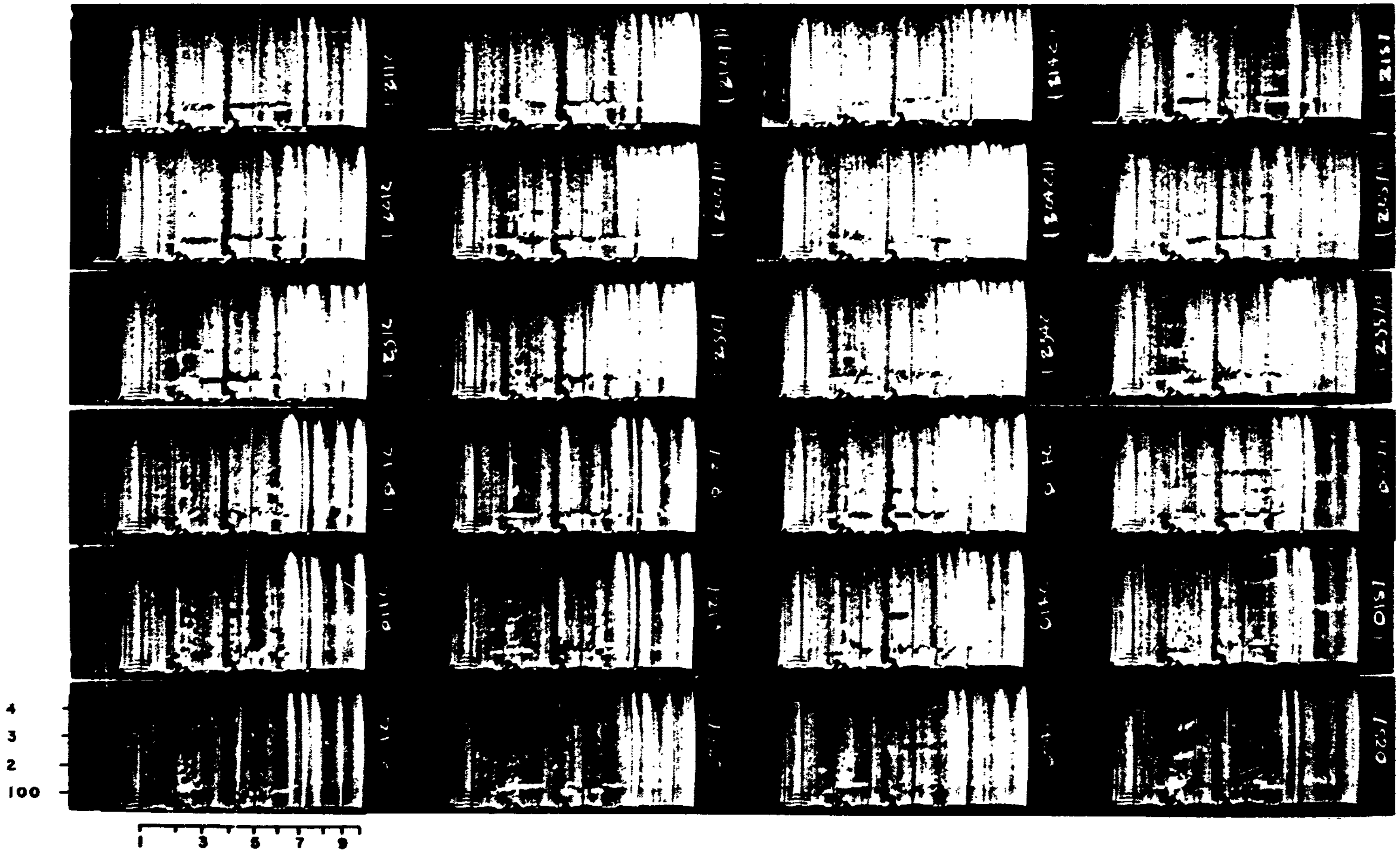
31 JULY 2312 - 2357 C=0.9
1 AUG 0012 - 0457 C=1.5



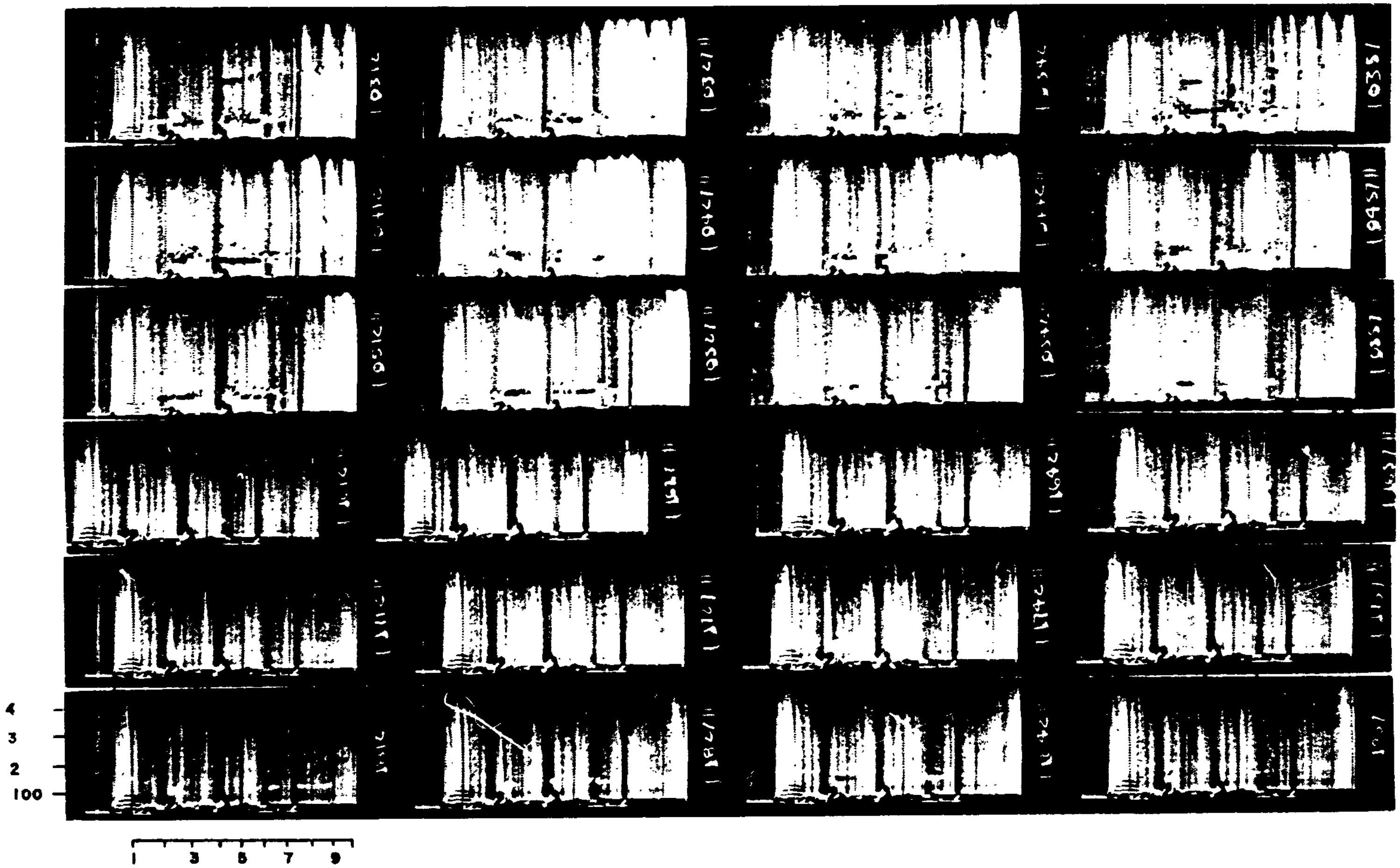
1 AUG 0512 — 0557 C=1.5
1 AUG 0412 — 2057 C=1.5



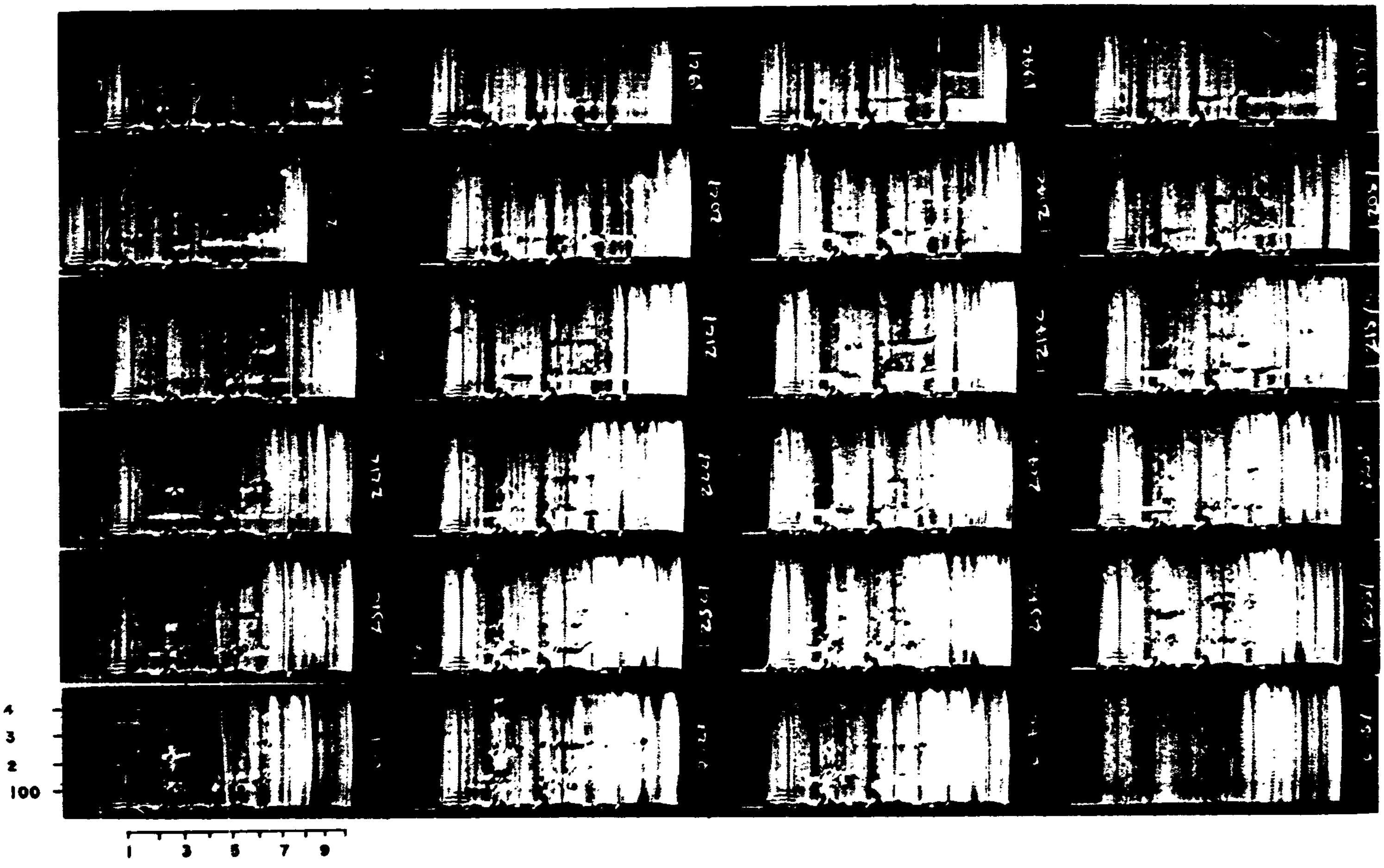
1 AUG 2112 - 2157 C=1.5
2 AUG 1612 - 2057 C=0.8



2 AUG 2112 - 2357 C=0.8
3 AUG 0012 - 0257 C=0.8



3 AUG   0312 – 0557   C = 0.8
3 AUG   1612 – 1857   C = 0.8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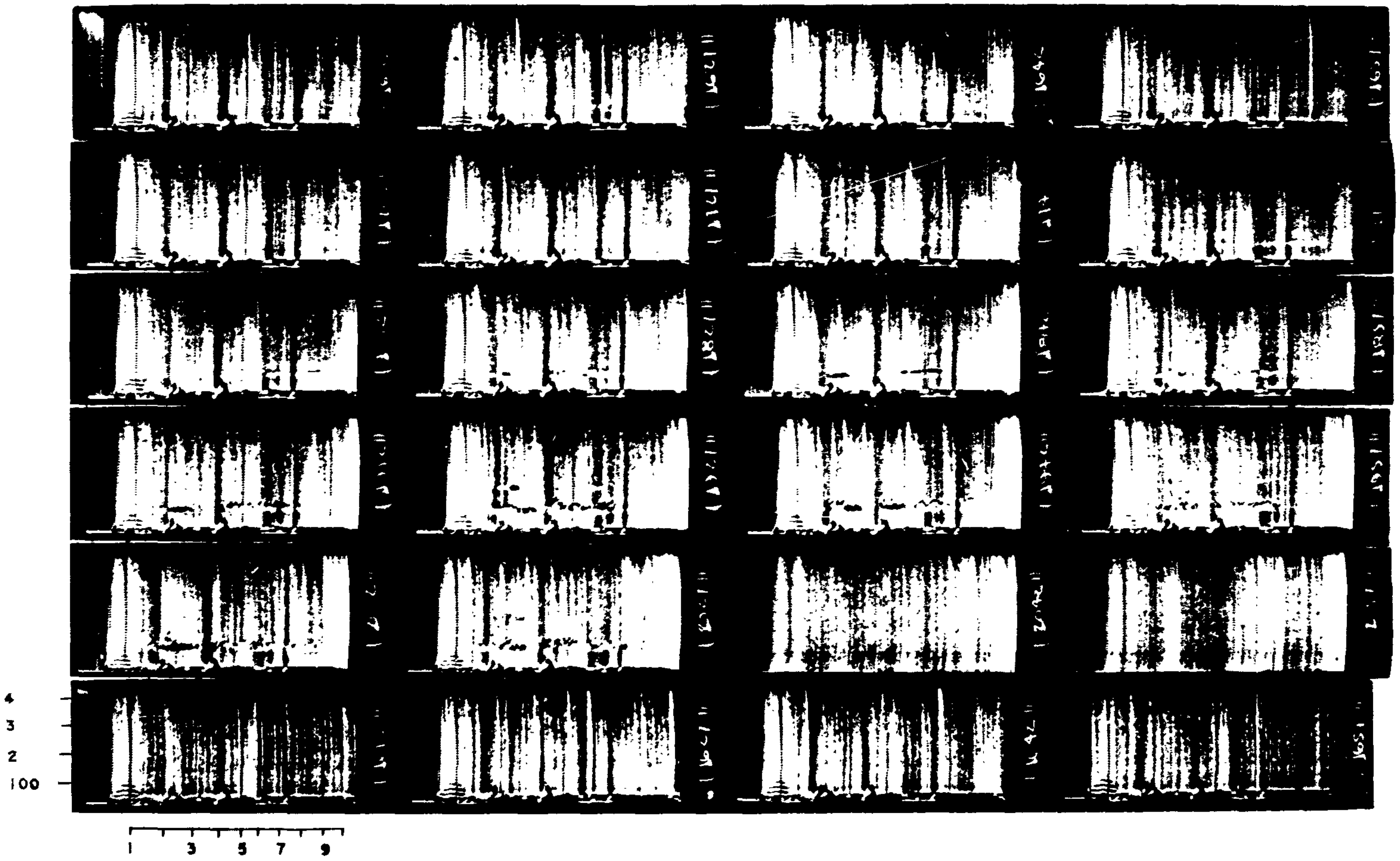
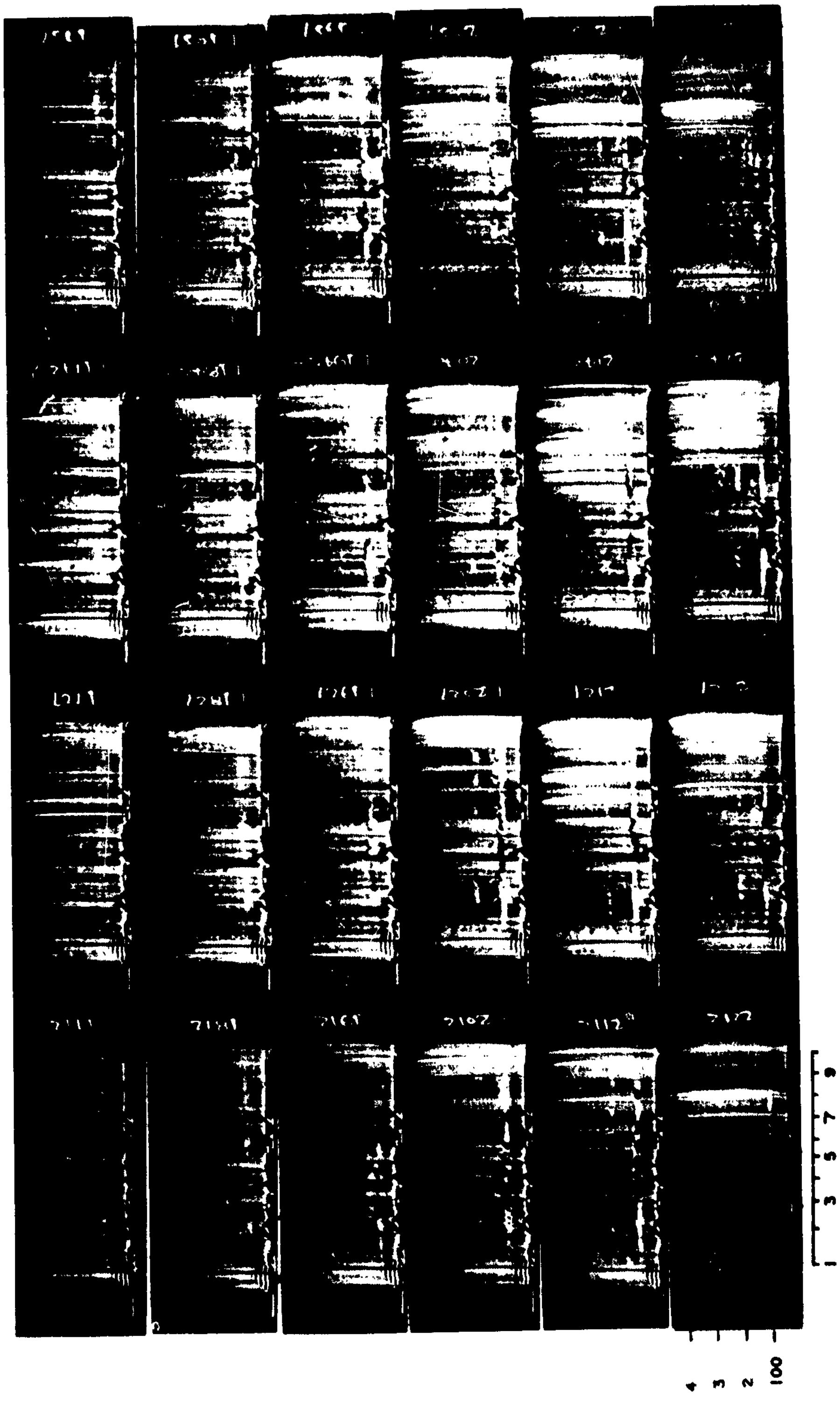
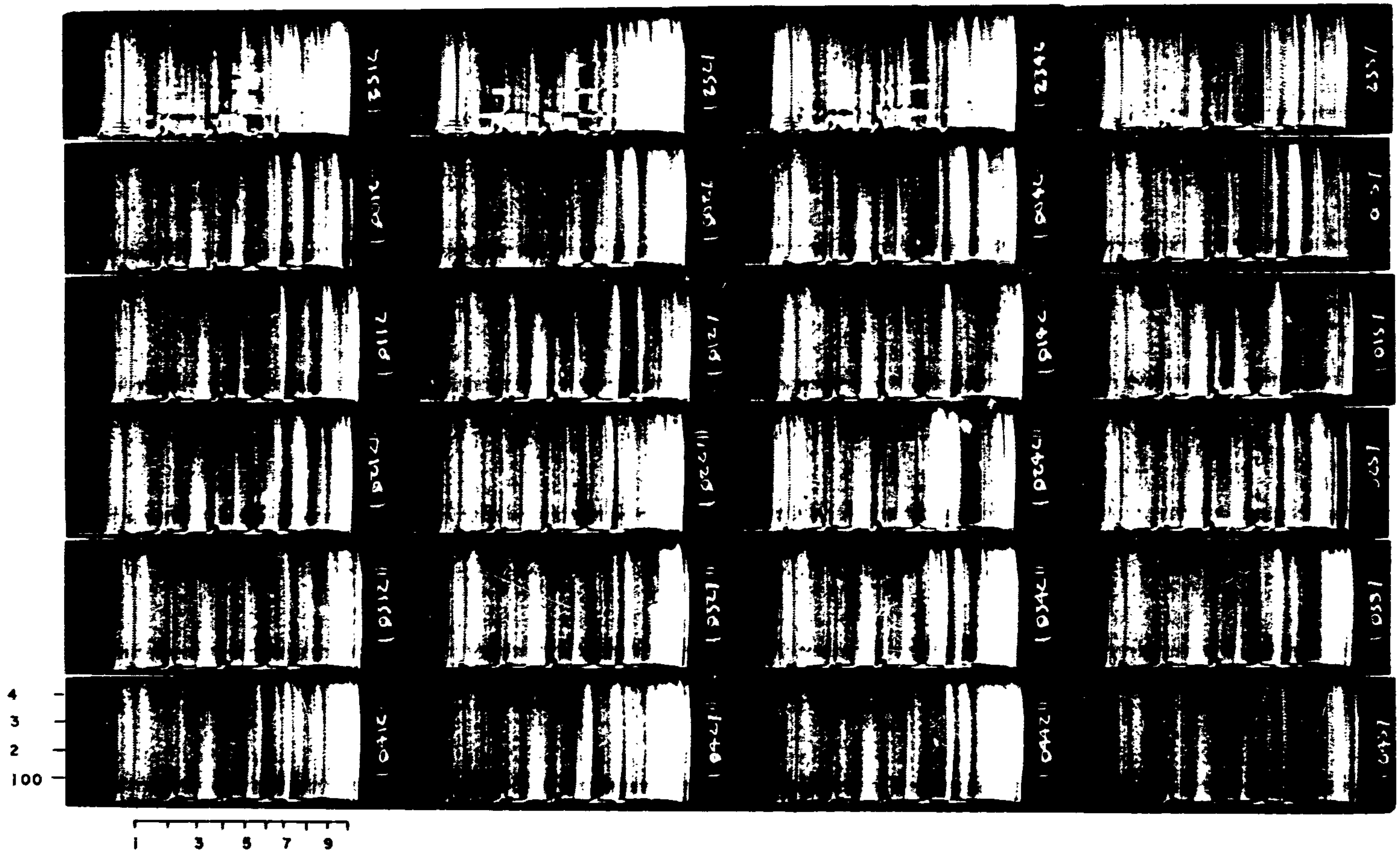
3 AUG 1912 - 2357 C=0.8
4 AUG 0012 - 0057 C=0.4



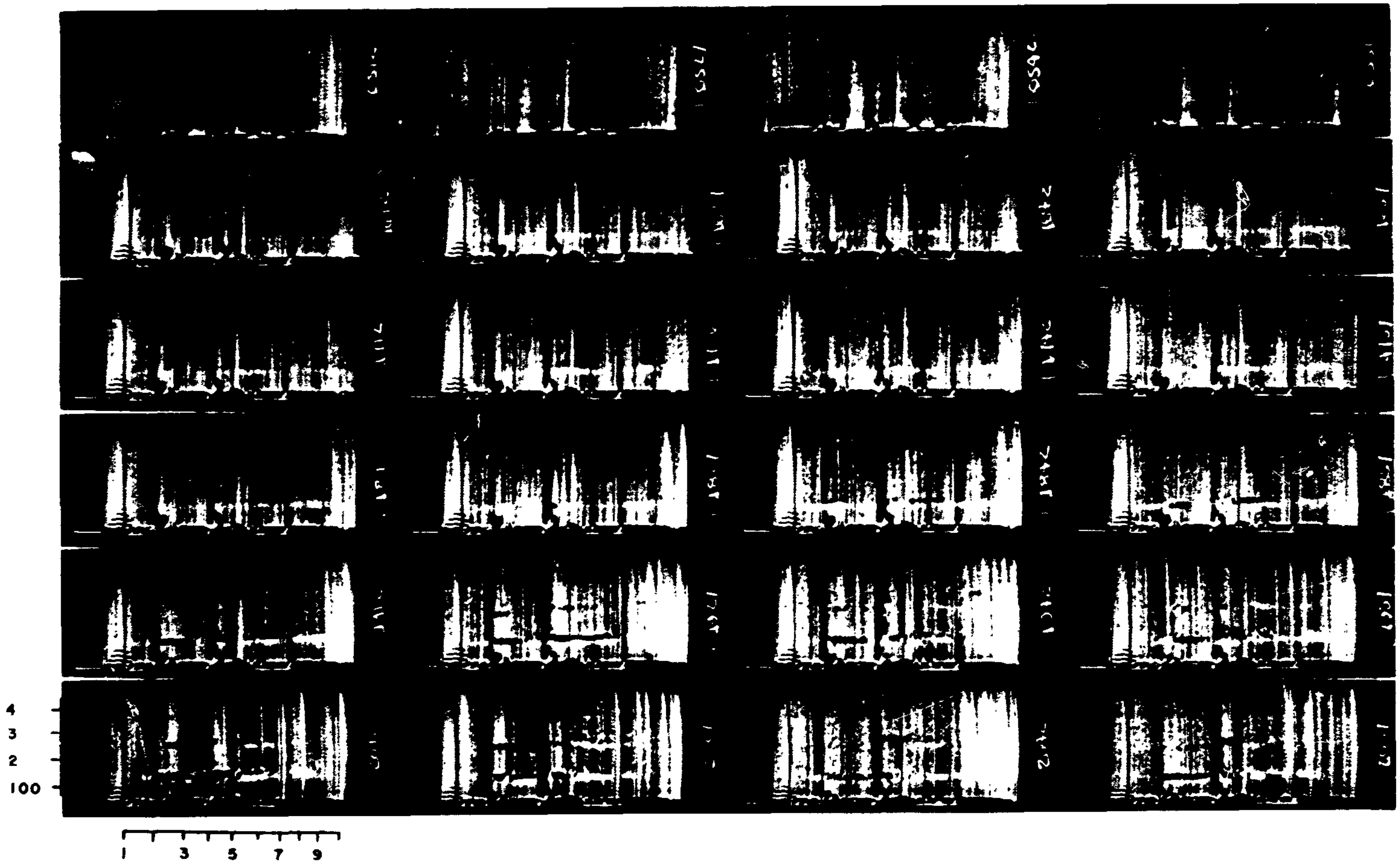
4 AUG 1612 – 2057 C = 0.4
5 AUG 1612 – 1657 C = 0.5



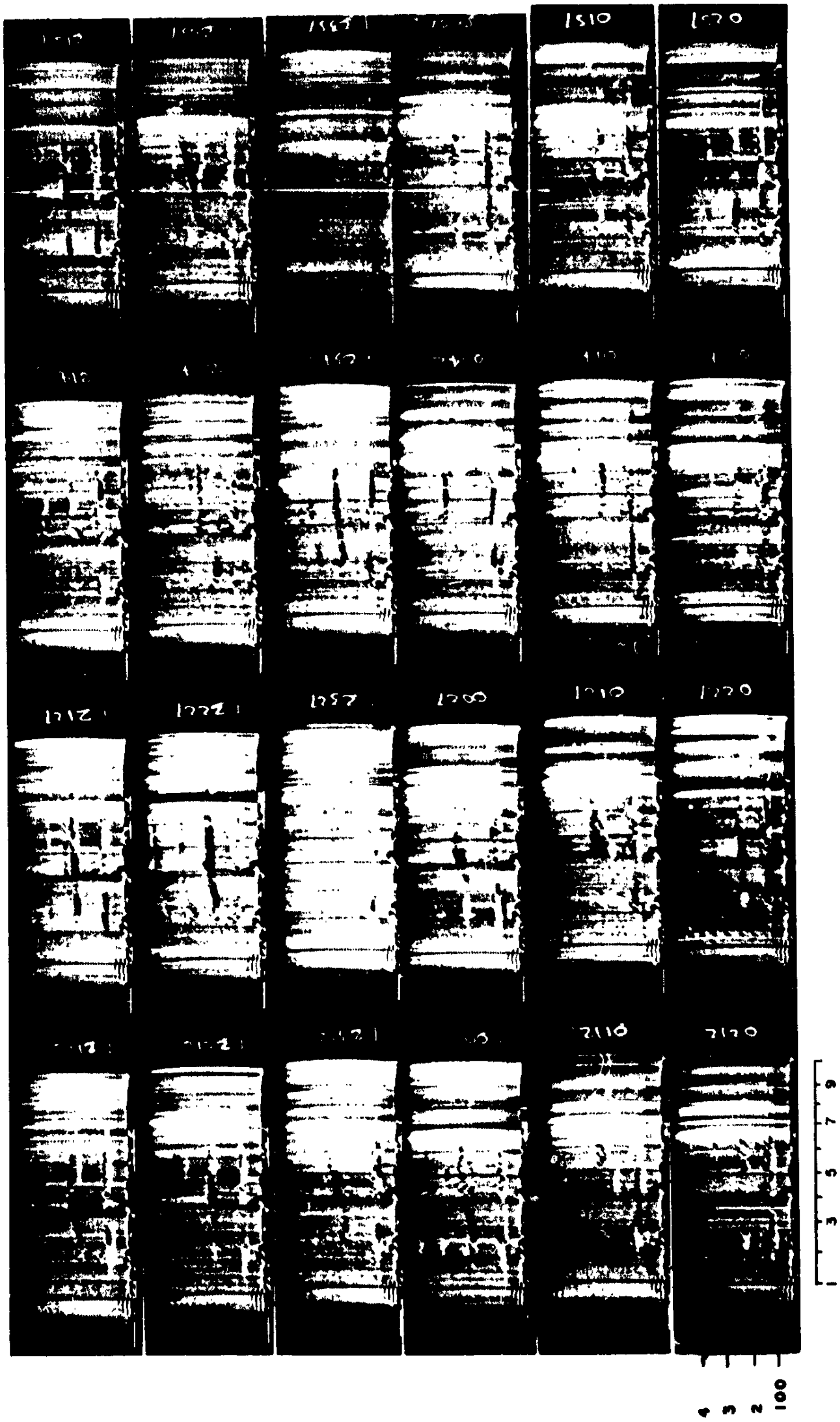
5 AUG 1712 – 2257 C = 0.5



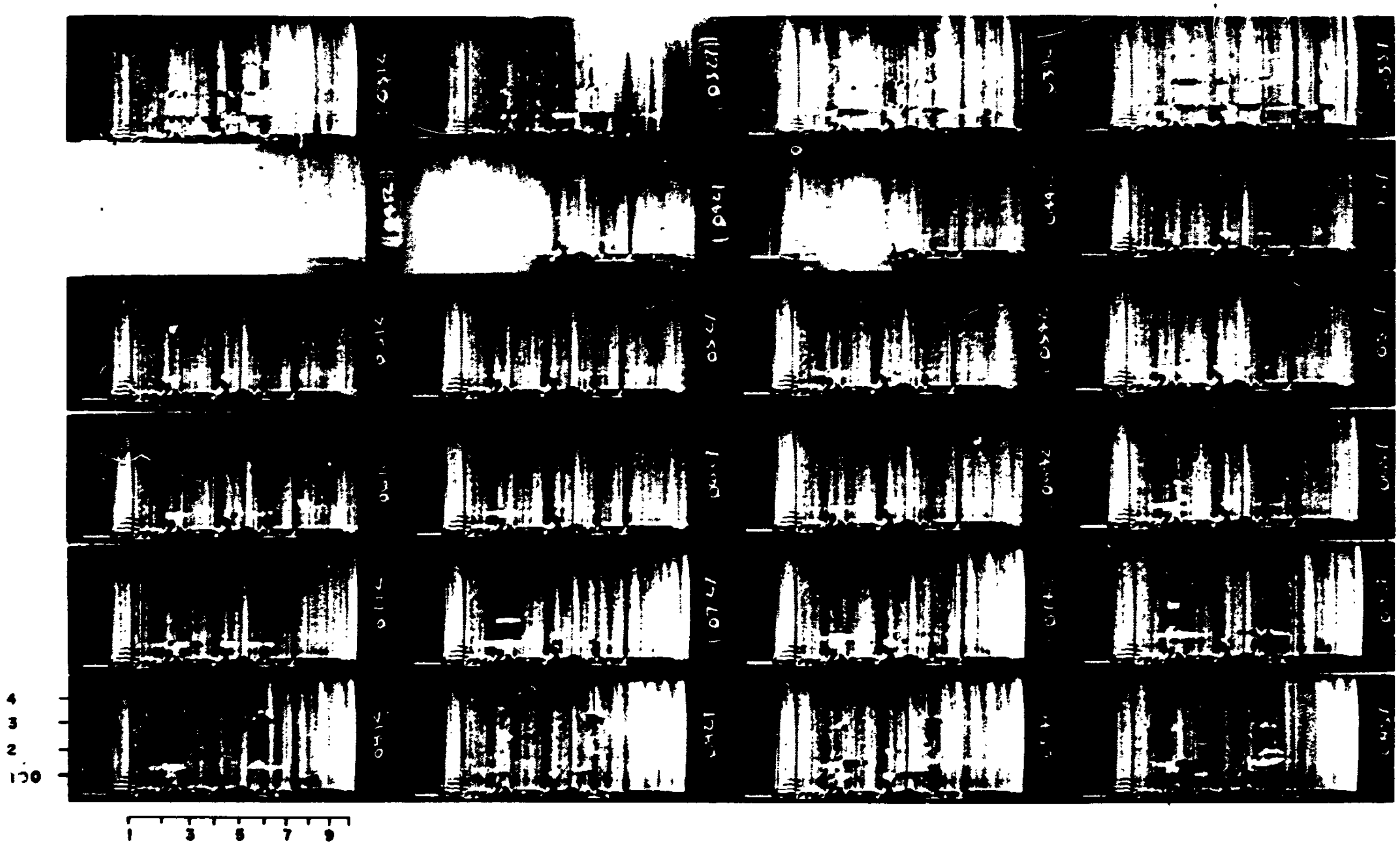
5 AUG 2312 - 2357 C=0.5
6 AUG 0012 -0457 C=1.0



6 AUG 0512 - 0557 C = 1.0
6 AUG 1612 - 2057 C = 1.0



6 AUG 2112 - 2357 C = 1.0
7 AUG 0012 - 0257 C = 1.1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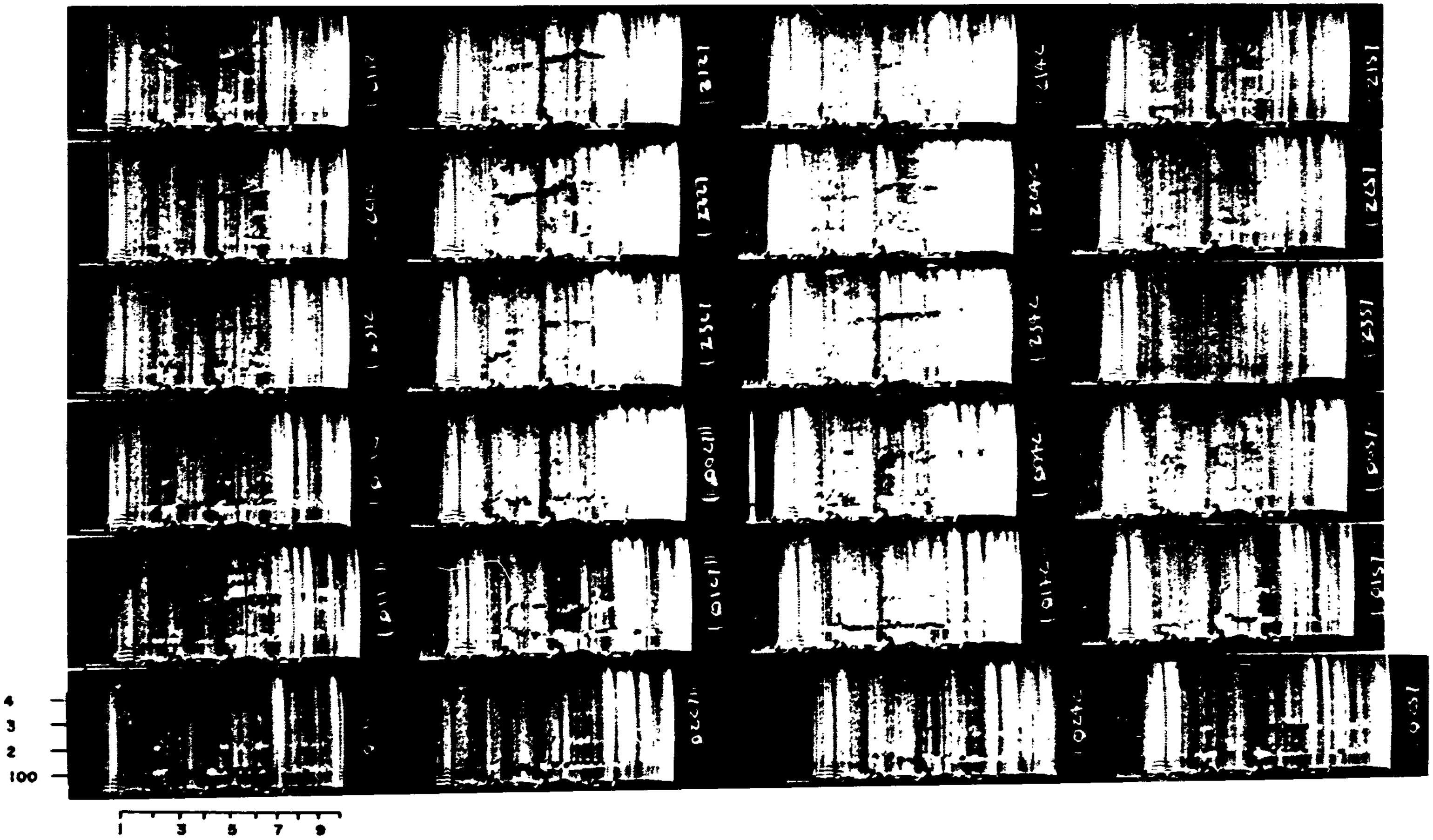
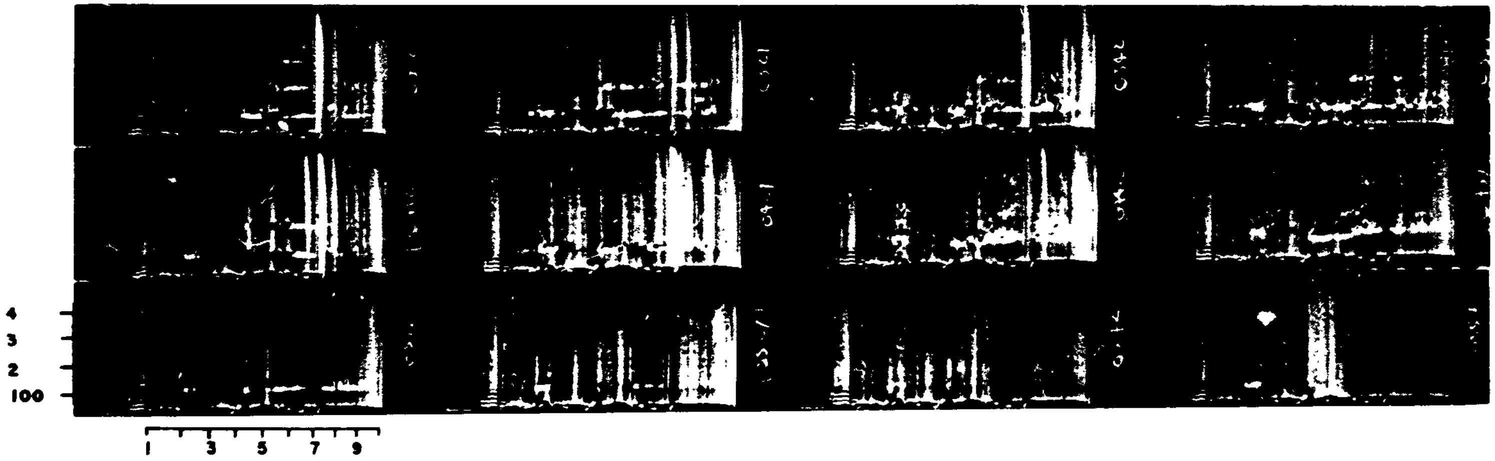
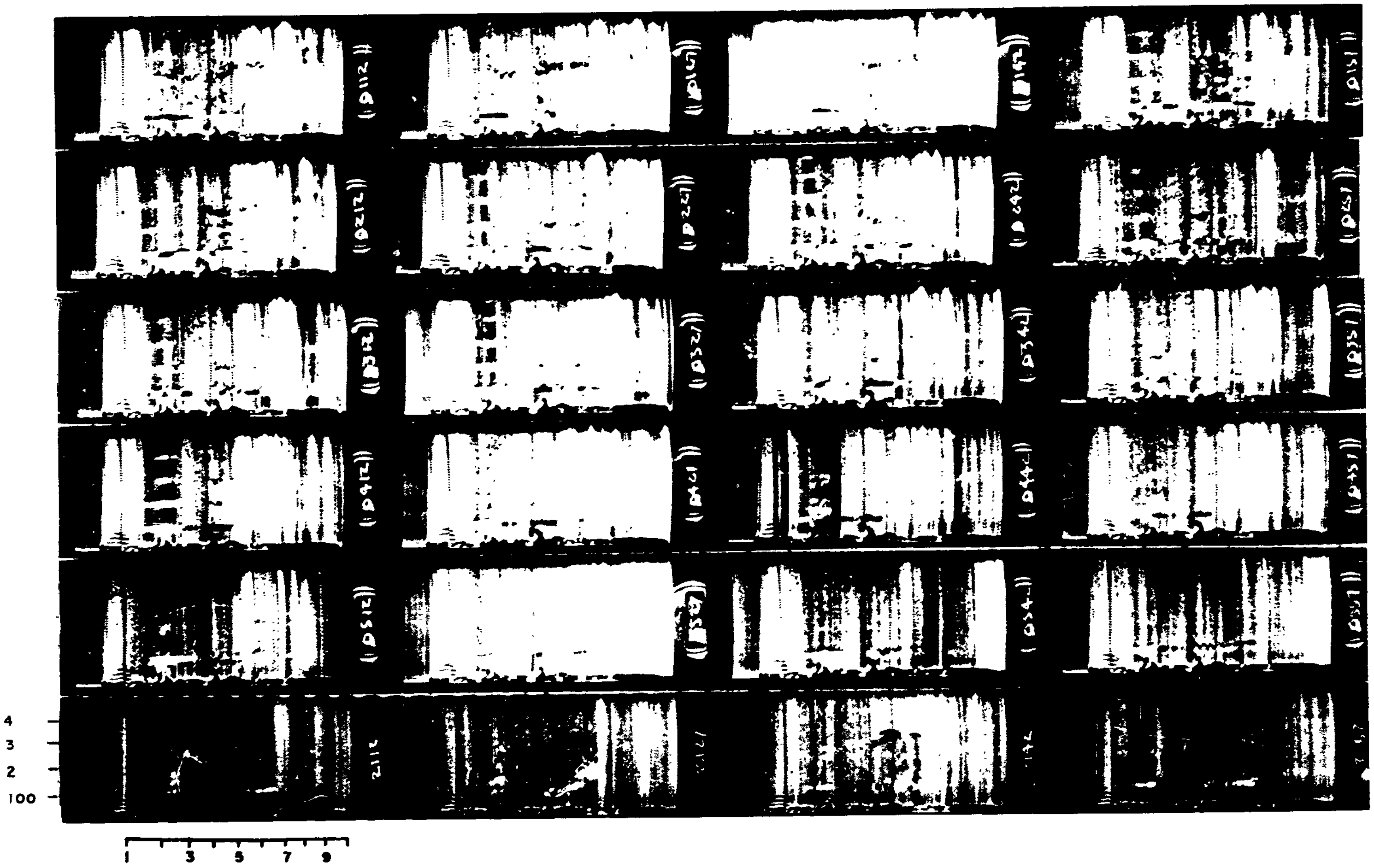
7 AUG 0312 - 0357 C = 1.1
7 AUG 1612 - 0257 C = 1.1



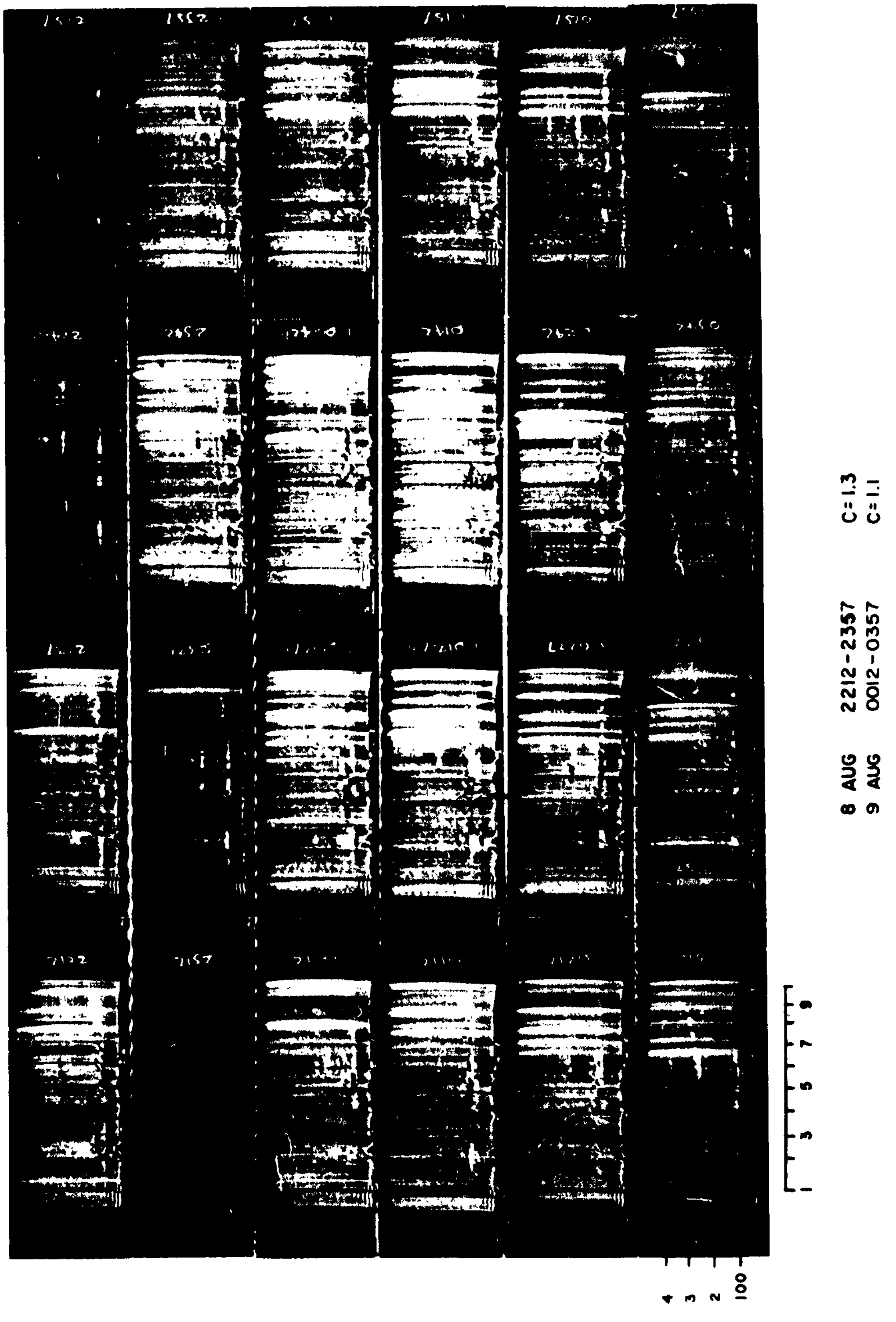
7 AUG 2112 - 2357 C = 1.1
8 AUG 0012 - 0257 C = 1.3



8 AUG 0312 - 0557 C = 1.3



20 AUG 0112-0557 C=0.2
8 AUG 2112-2157 C=1.3


8 AUG 2212-2357 C=1.3
9 AUG 0012-0357 C=1.1
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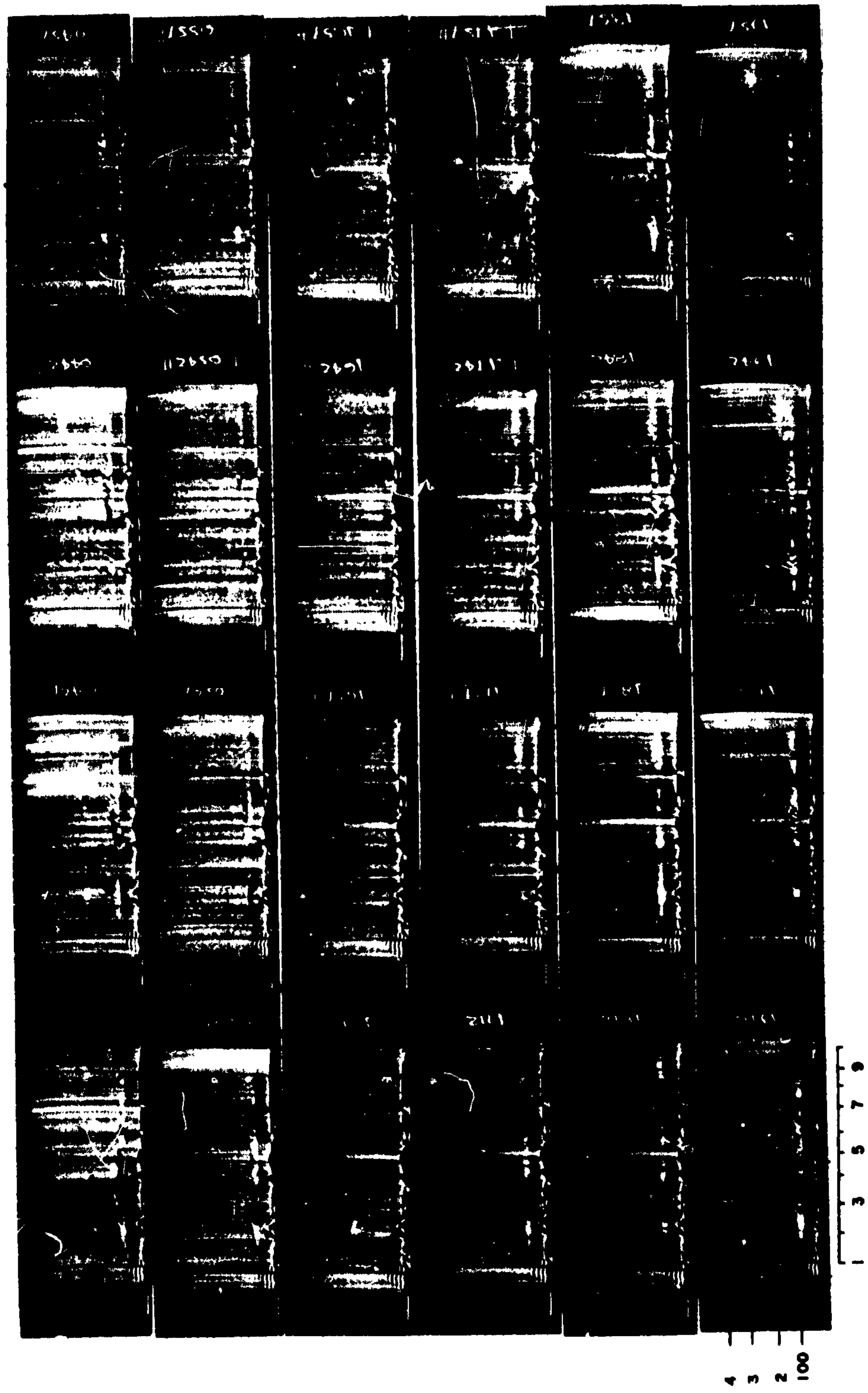
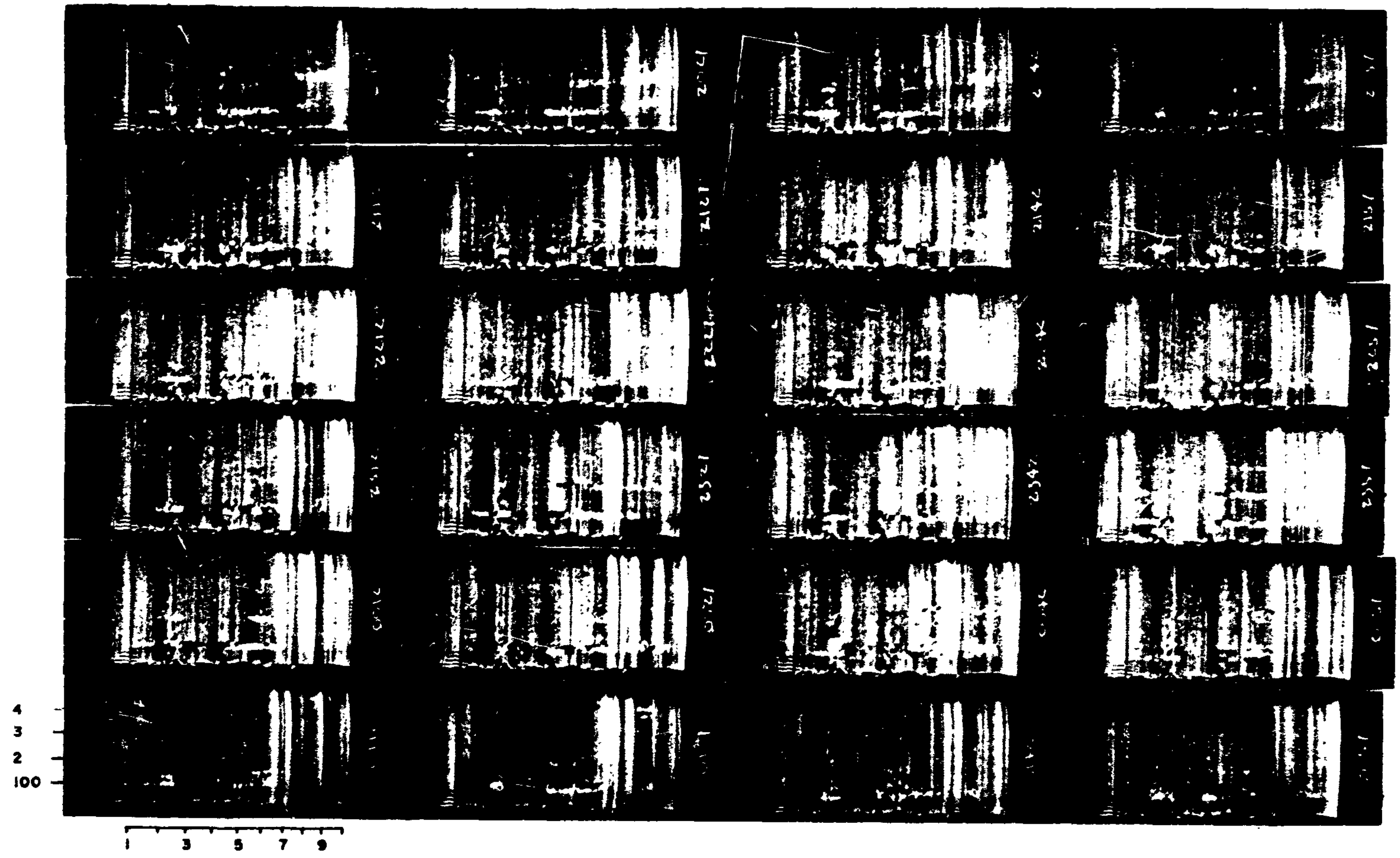
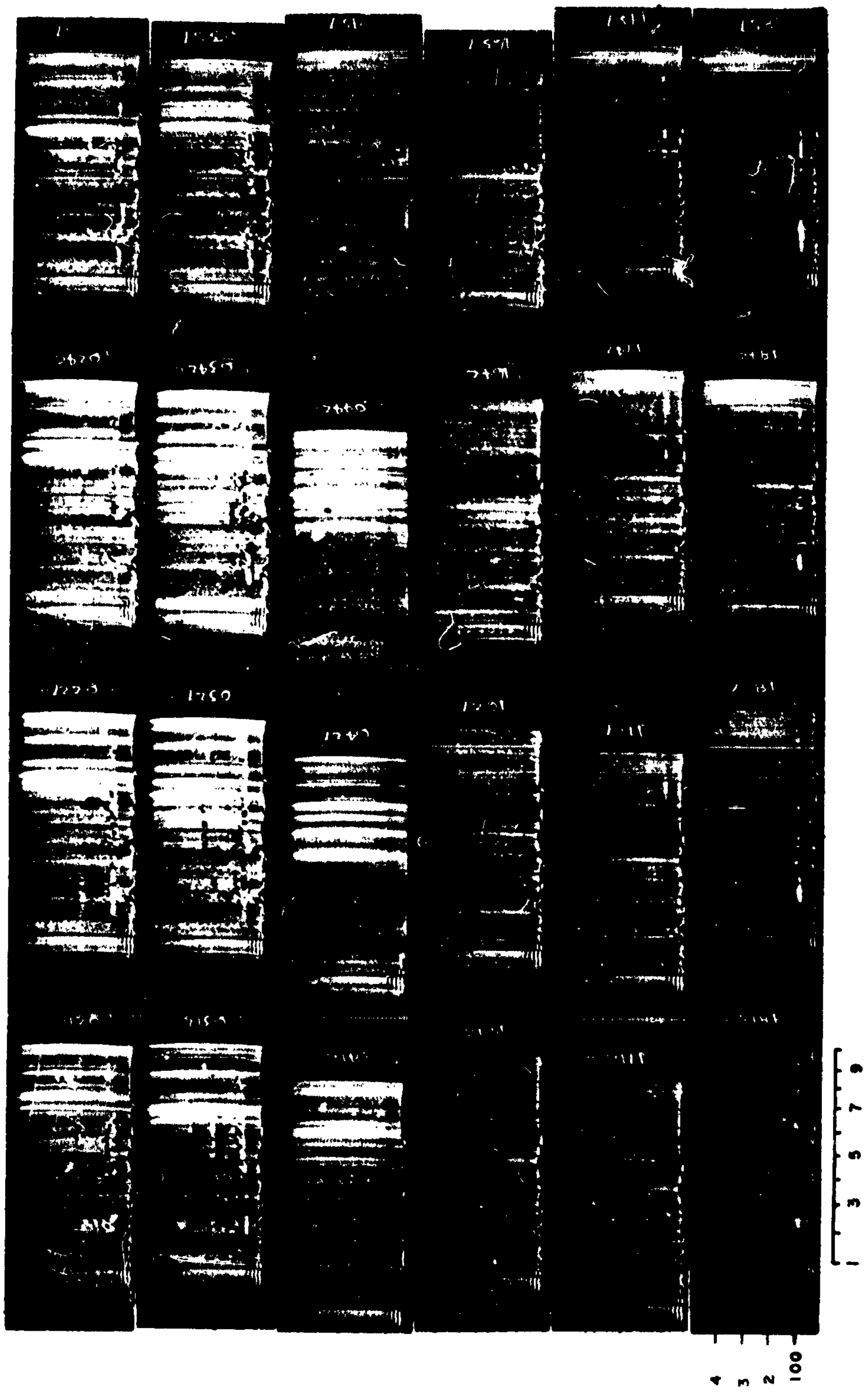


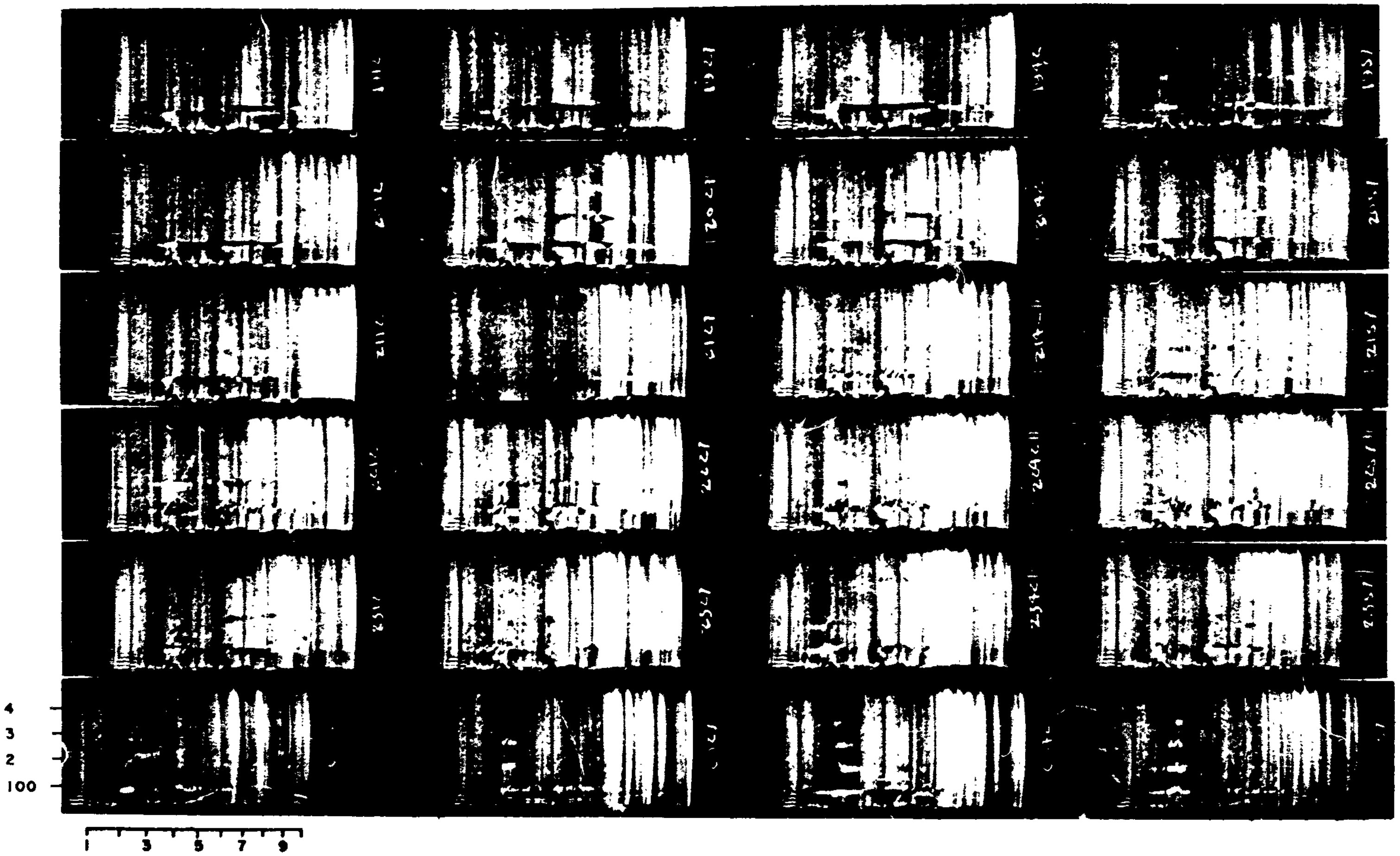
9 AUG 0412-0557 C=1.1
9 AUG 1612-1957 C=1.1



9 AUG 2021-2357 C=1.1
10 AUG 0012-0157 C=0.7



10 AUG 0212-0557 C=0.7
10 AUG 1812-1857 C=0.7



10 AUG 1912-2357 C=0.7
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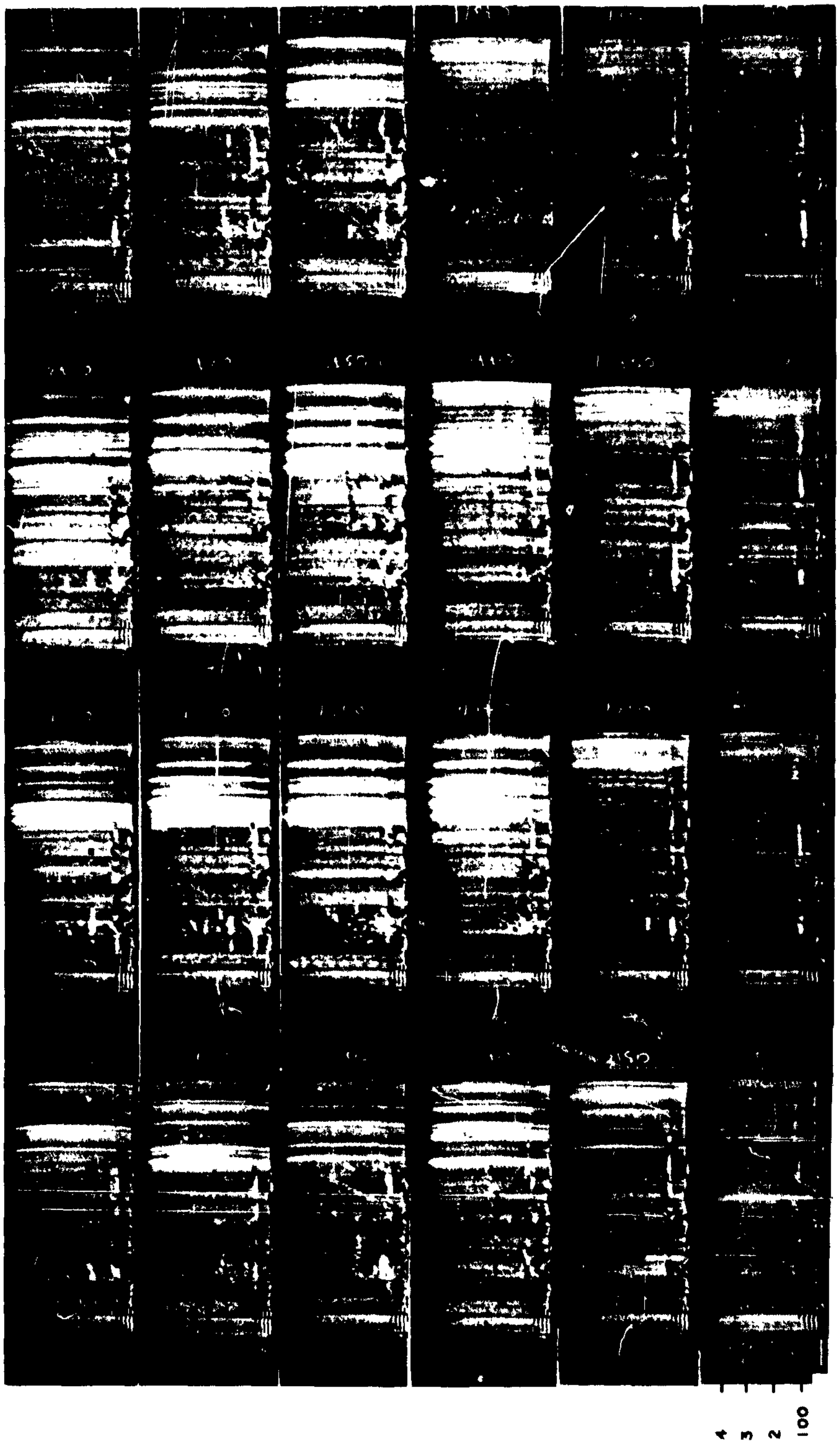
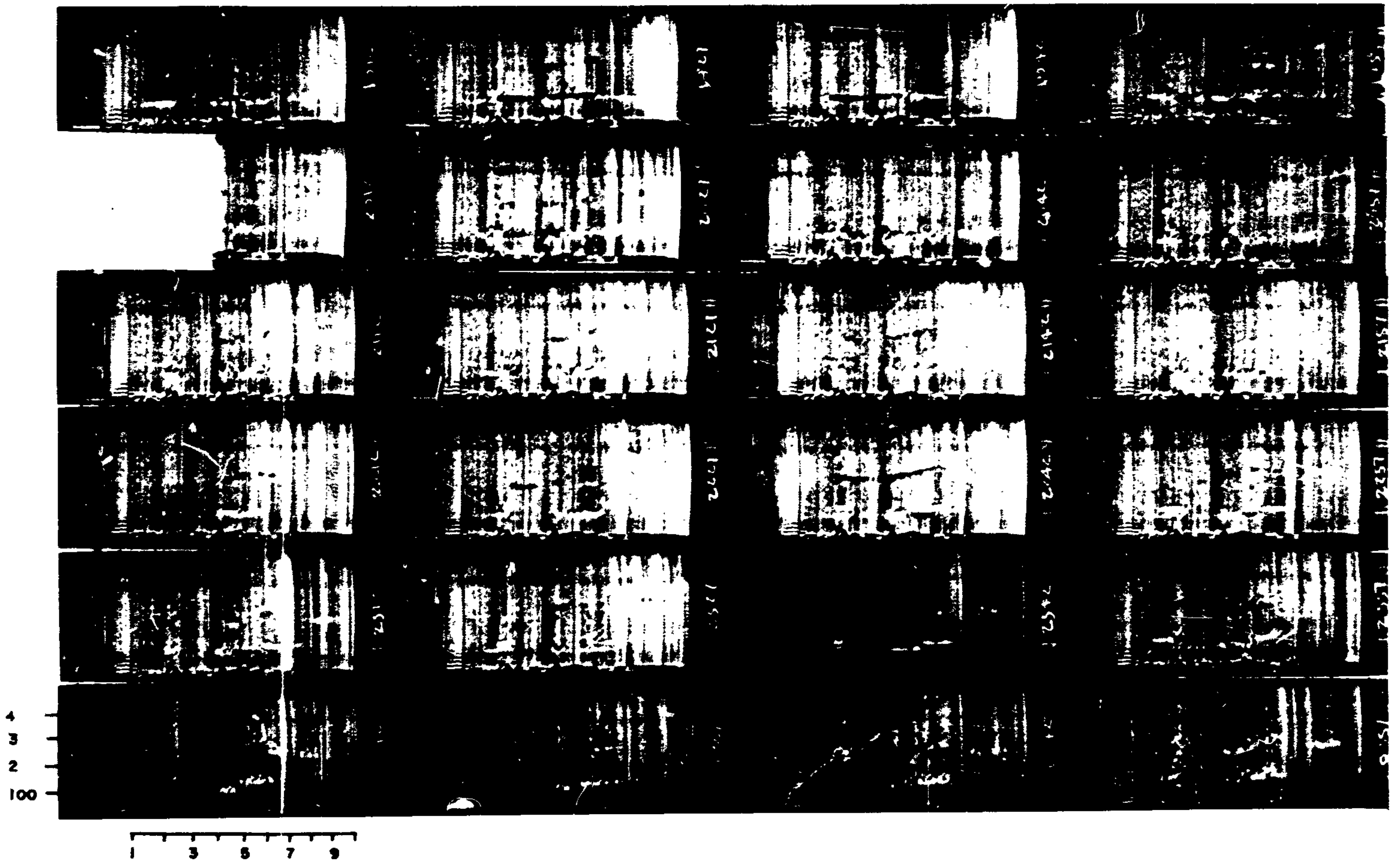
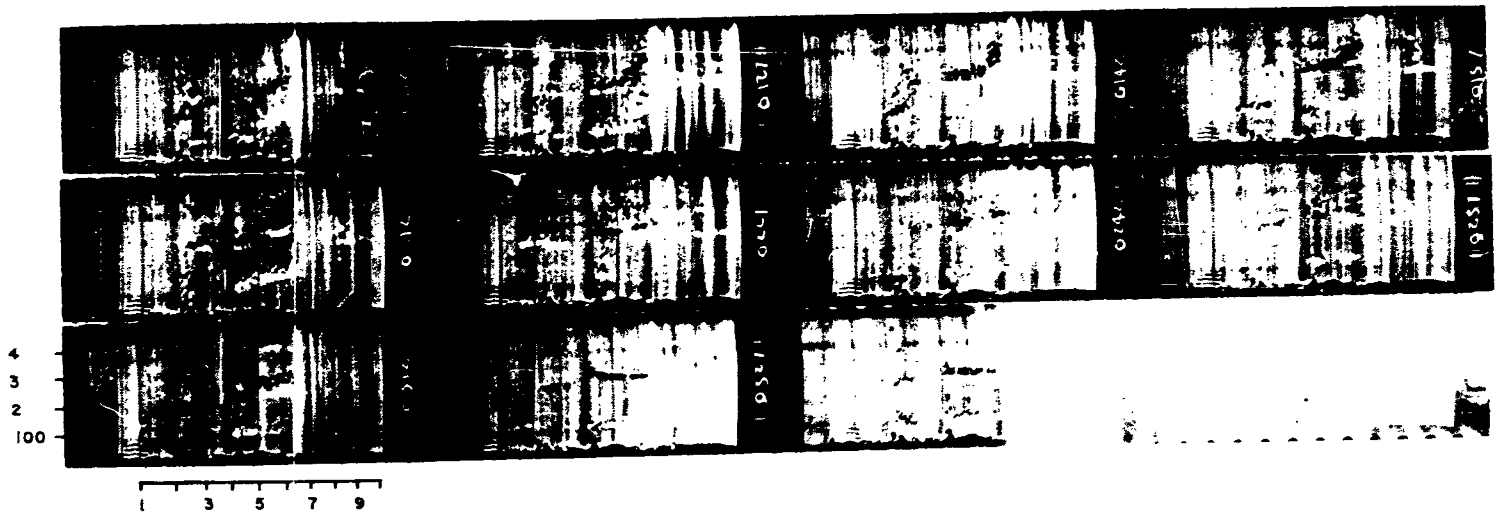


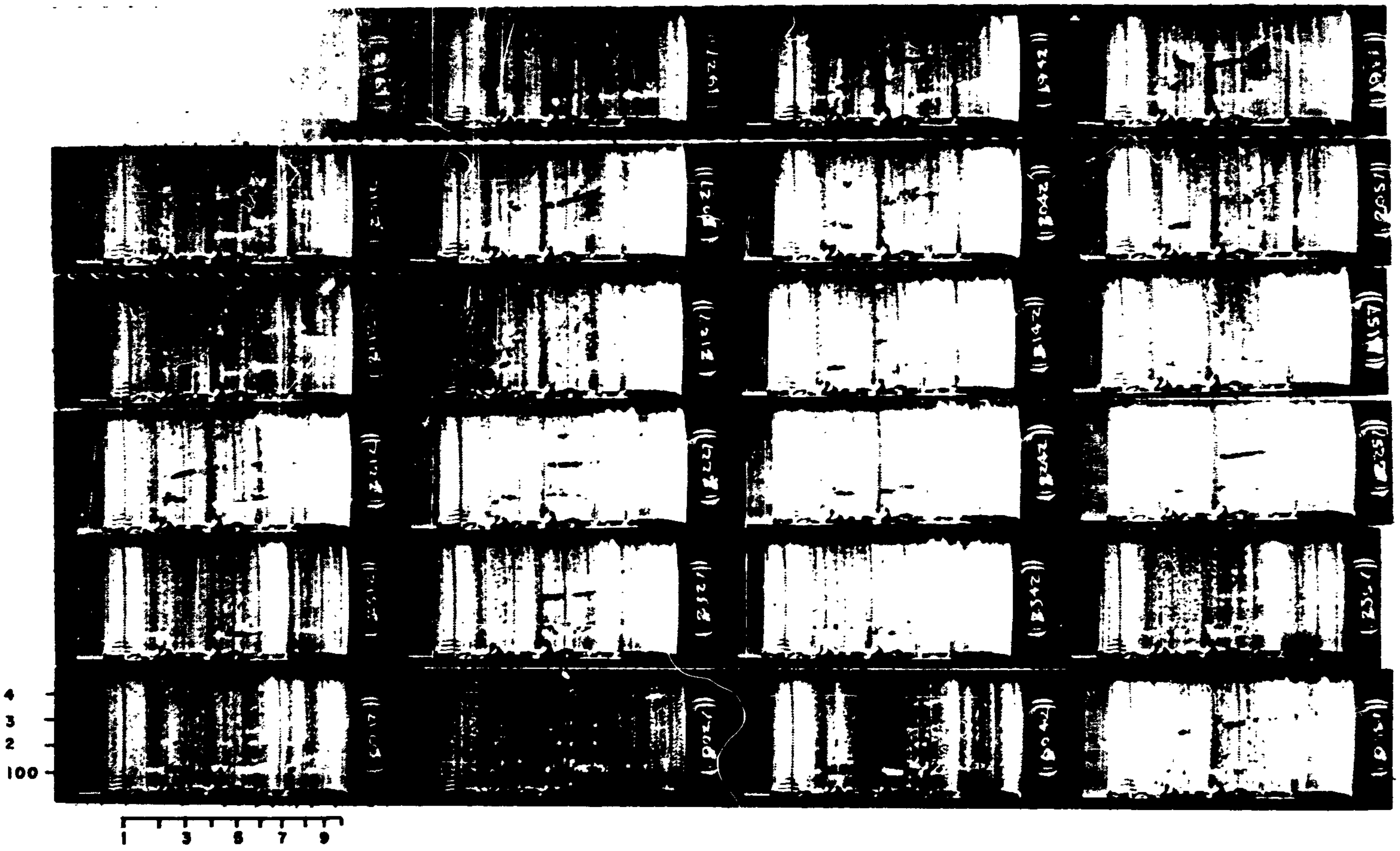
11 AUG 0112-0557 C=0.0
15 AUG 1812-1857 C=1.1



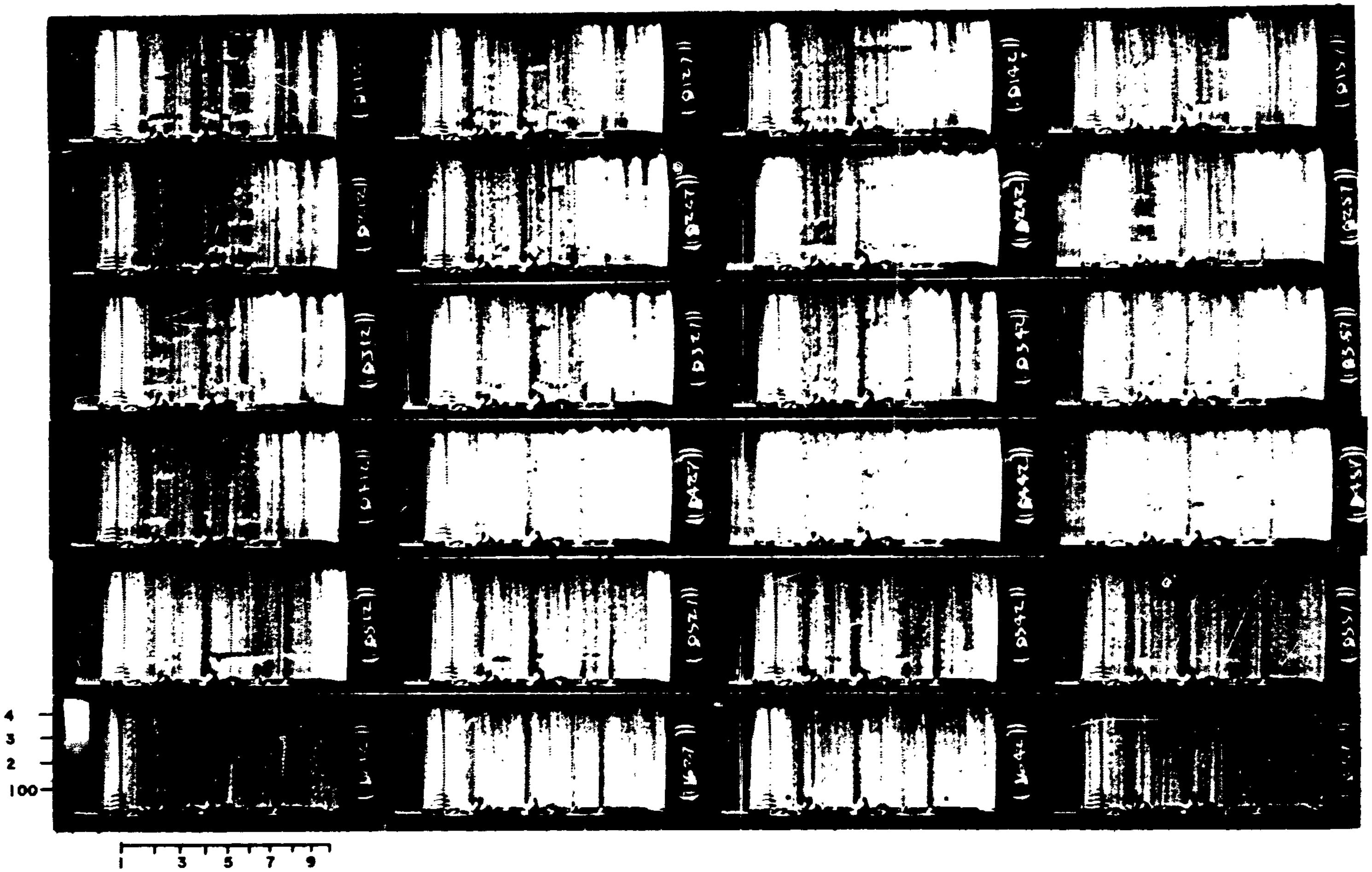
15 AUG 1912-2357 C=1.1
16 AUG 0012-0057 C=1.1



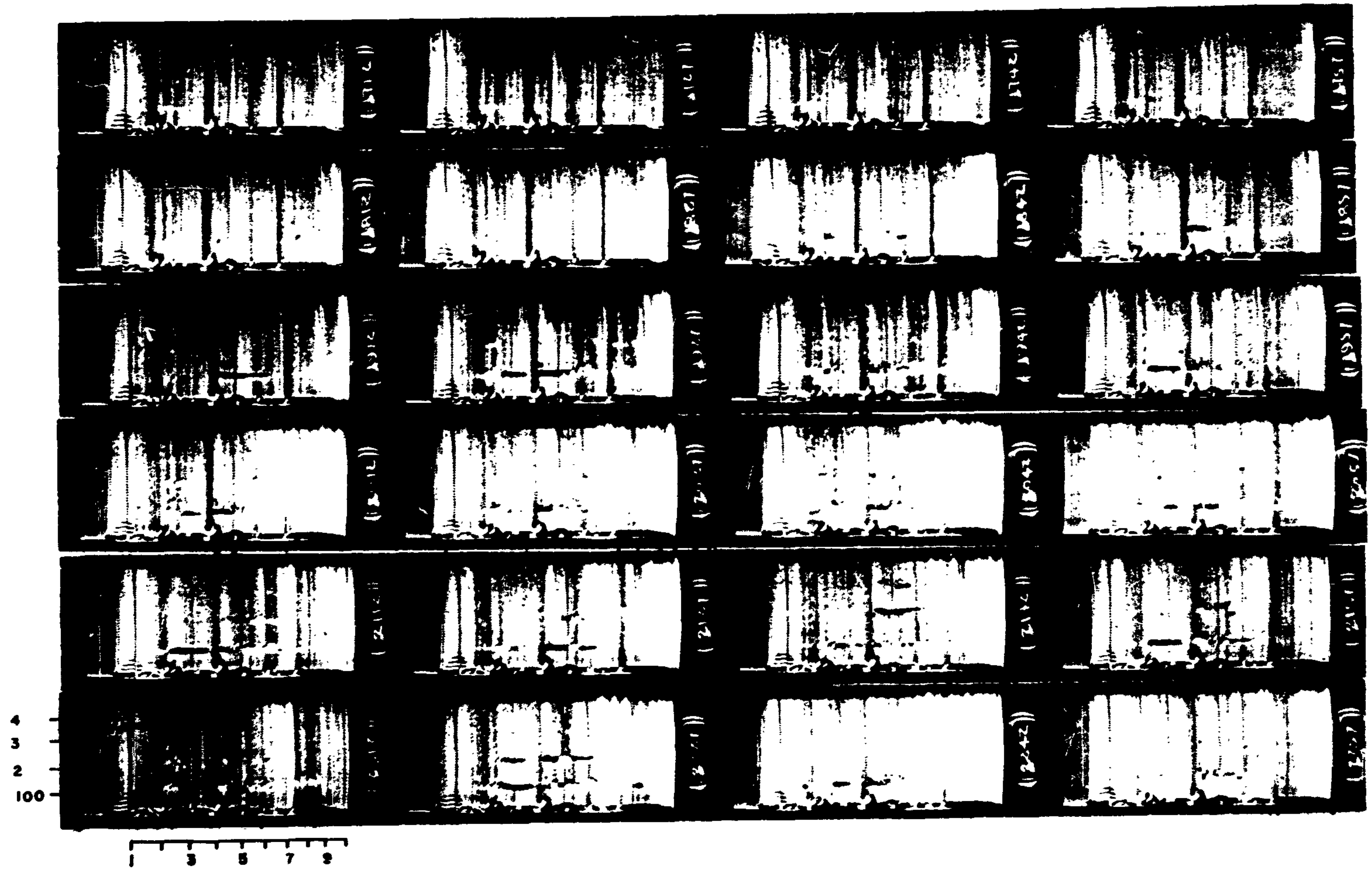
16 AUG 0112-0357 C=1.1



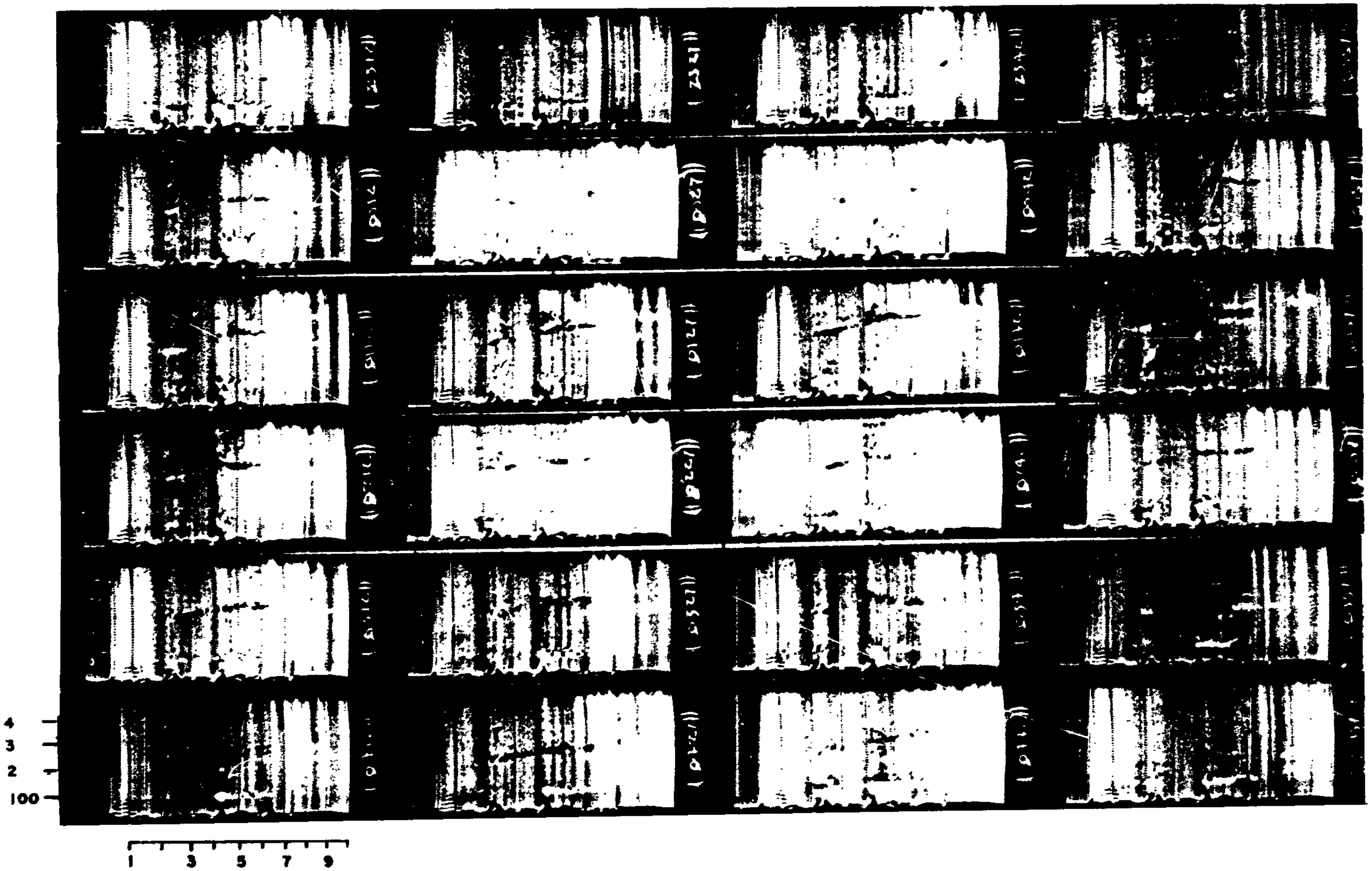
16 AUG 1912-2357 C=1.1
17 AUG 0012-0057 C=1.2



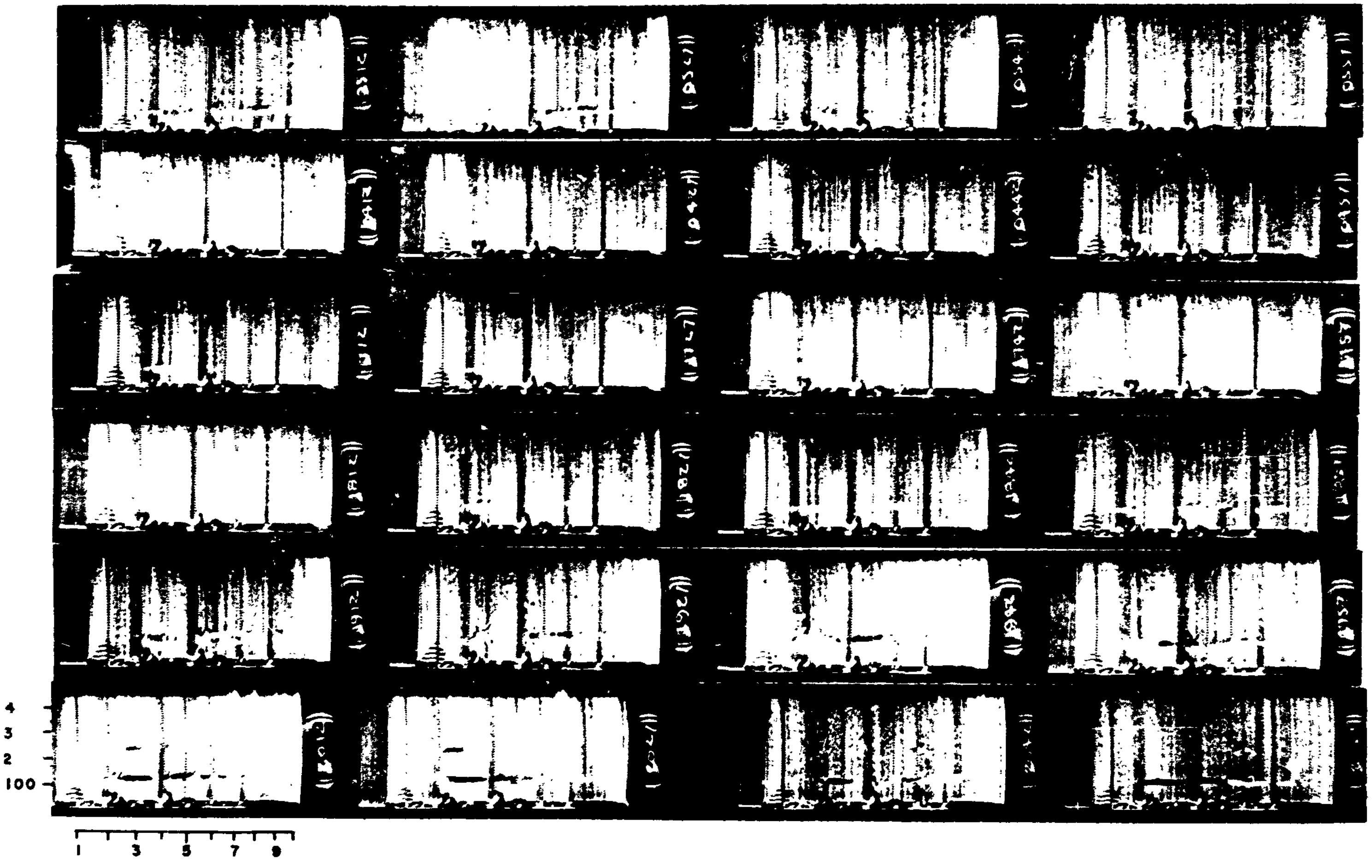
17 AUG 0112-0557 C=1.2
17 AUG 1612-1657 C=1.2



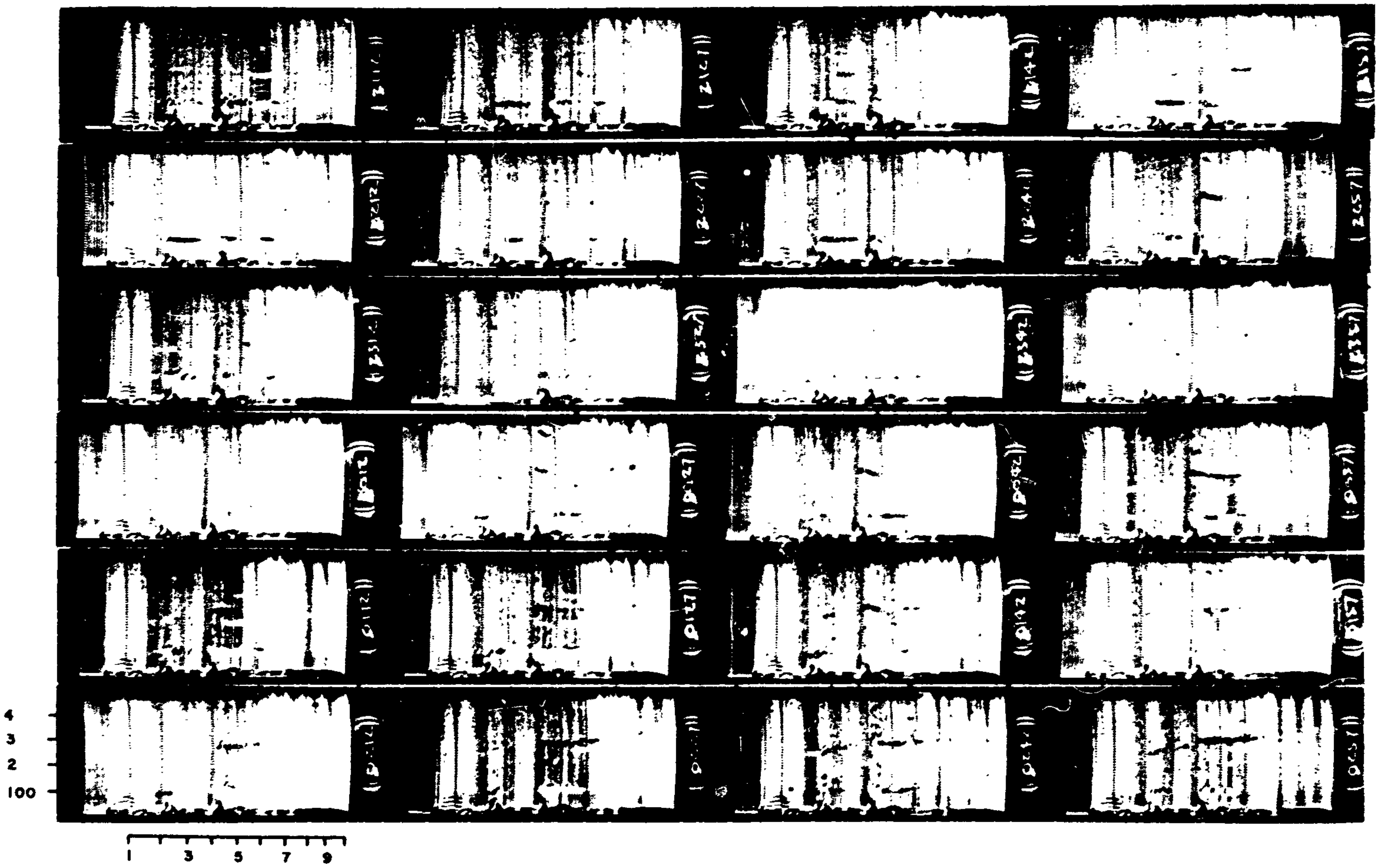
17 AUG 1712-2257 C=1.2



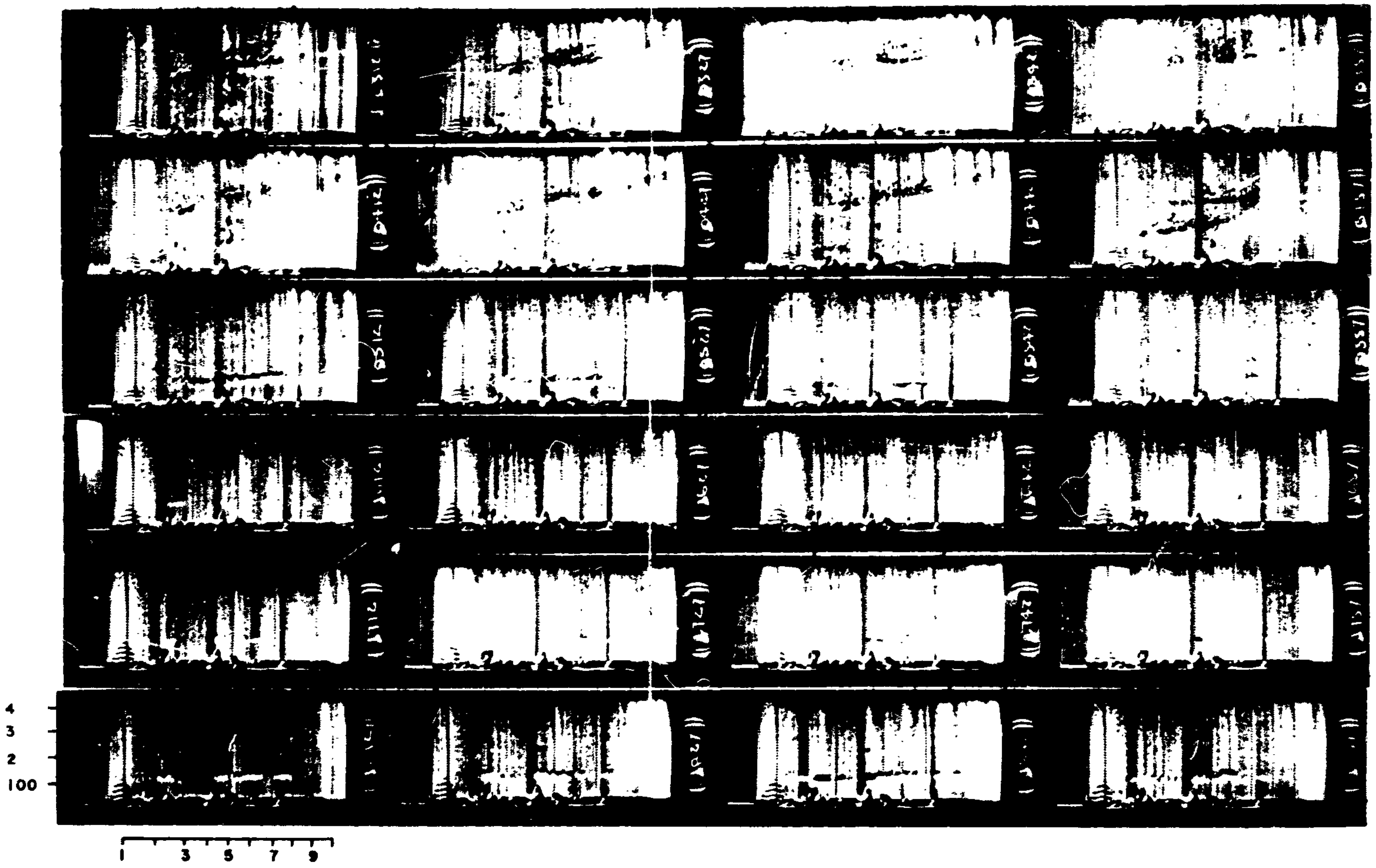
17 AUG 2312-2357 C=1.2
18 AUG 0012-0457 C=1.1



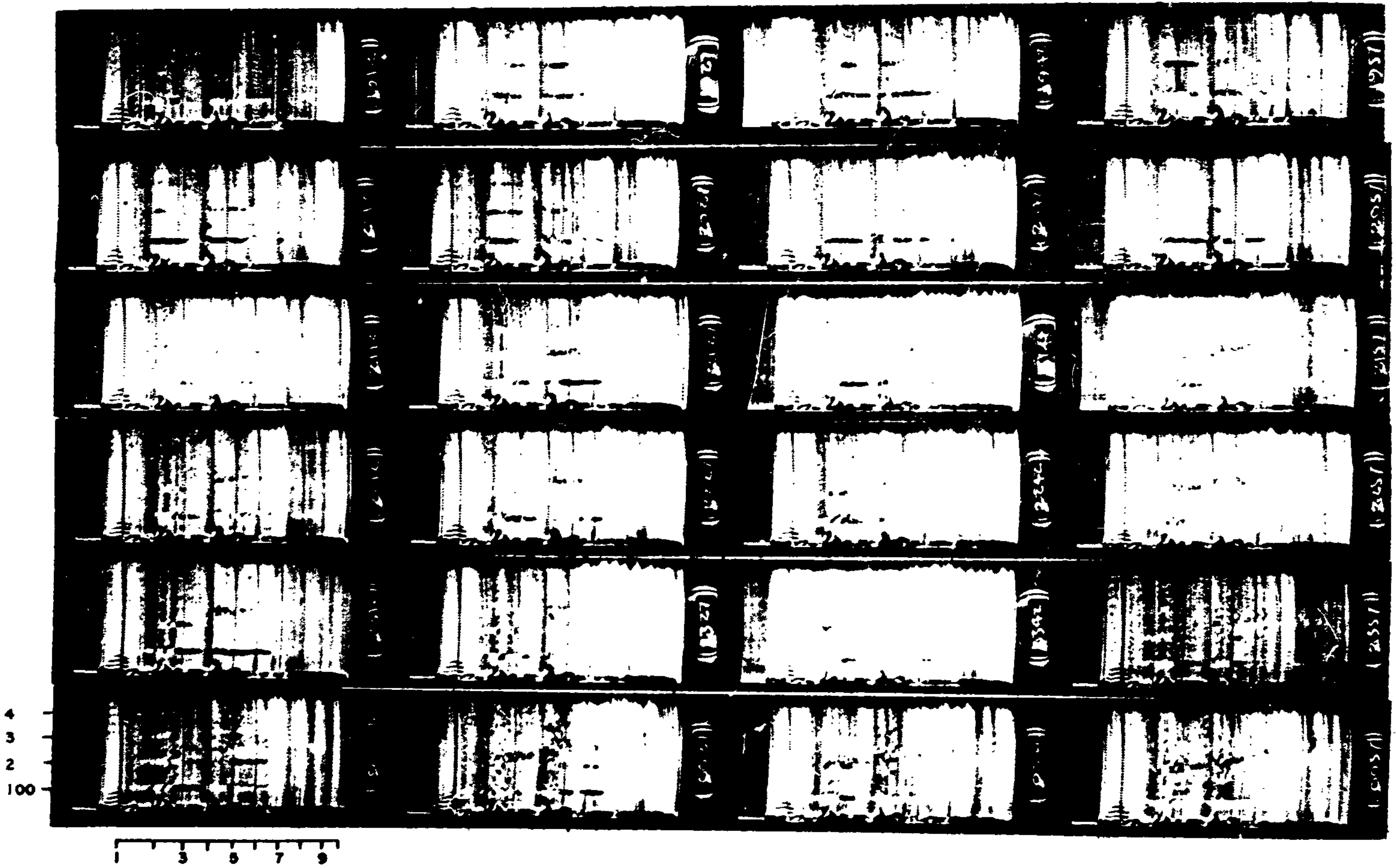
18 AUG 0512-0557 C=1.1
18 AUG 1612-2057 C=1.1



18 AUG 2112-2357 C=1.1
19 AUG 0012-0257 C=1.0



19 AUG 0312-0557 C=1.0
19 AUG 1612-1857 C=1.0



19 AUG 1912-2357 C=1.0
20 AUG 0012-0057 C=0.2